

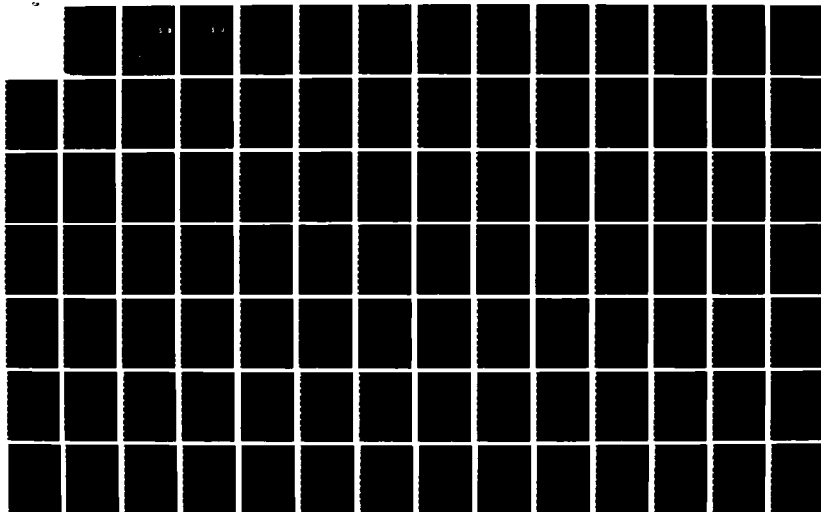
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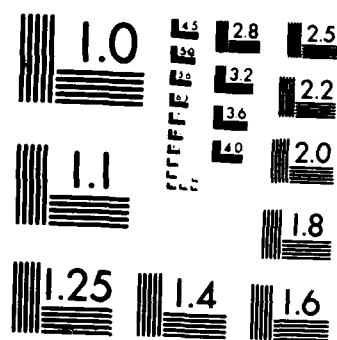
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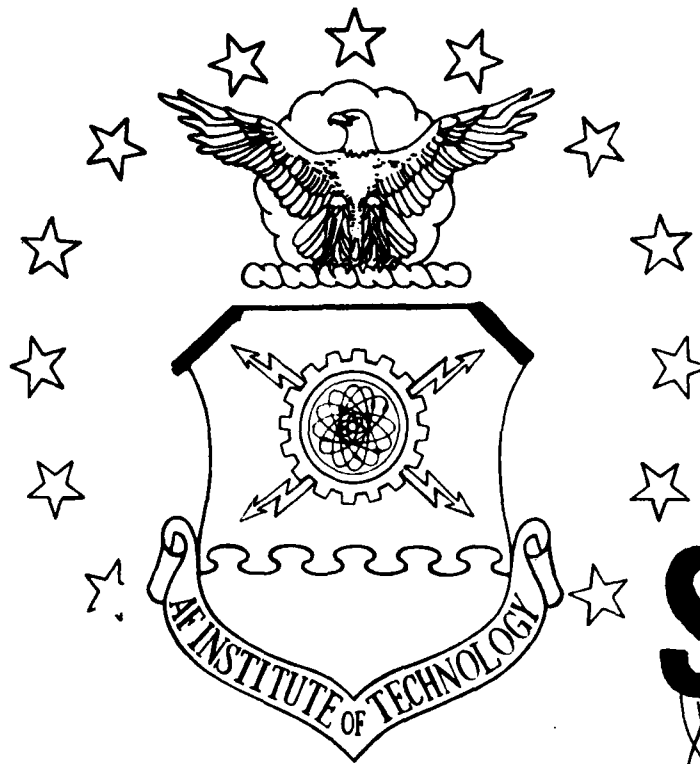
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THESIS

James E. Blacken, Jr.  
Captain, USAF

AFIT/GSM/LSY/86S-2

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AN INVESTIGATION OF THE IMPACT OF CONTRACT  
CHANGES ON COST GROWTH WITHIN THE LANTIRN SYSTEM  
PROGRAM OFFICE

THESIS

Presented to the Faculty of the School of Systems and Logistics  
of the Air Force Institute of Technology  
Air University  
In Partial Fulfillment of the  
Requirements for the Degree of  
Master of Science in Systems Management

James E. Blacken, Jr., B.S.  
Captain, USAF

September 1986

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James E. Blacken, Jr.

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Abstract

The acquisition of new weapon systems is a multi-billion dollar industry, whose cost is matched in magnitude only by its complexity. Quite frequently the final costs of these weapon systems greatly exceed their original cost estimates. Initiatives have been aimed at acquisition cost reduction, but to a large extent the problem still persists.

The purpose of this investigation is to explore possible means for improving the efficiency and cost-effectiveness of the acquisition management process. This study examines the contract amendments that transpired during the Full Scale Engineering Development (FSED) phase of the Low Altitude Navigation and Targeting Infrared System for Night (LANTIRN) weapon system, managed under the Deputate for Reconnaissance, Strike, and Electronic Warfare of Aeronautical Systems Division. Contract changes and their subsequent costs are grouped relative to their impact on (1) the scope of the contract, (2) the product delivery schedule of the contract, and (3) the design of the weapon system. In addition, various other factors are considered such as the point in contract performance at which the change occurred, the length of the period of performance, the page length of the Engineering Change Proposal (ECP), and the page length

of the Statement of Work (SOW) alteration. All costs are adjusted to base year FY36 dollars to control for inflation.

Contract changes affecting the Statement of Work, including design changes, were found to contribute the greatest amount to contract cost. Extensions to the product delivery schedule also contributed significantly to contract change cost. The use of change orders to implement contract change produced increased costs, and no significant difference was found between the contractor's Not-to-Exceed estimate and final negotiated costs for change orders. Future LANTIRN contract actions should seek to minimize these activities.

# AN INVESTIGATION OF THE IMPACT OF CONTRACT CHANGES ON COST GROWTH WITHIN THE LANTIRN SYSTEM PROGRAM OFFICE

## I. Introduction

This chapter presents background information on the status of the systems acquisition segment of the Department of Defense budget and its relationship to the national economy. The specific research question is stated, along with a listing of the component investigative questions. Finally, conditions are identified which delimit the scope of this study.

### Background

As federal expenditures continue to increase, the national defense budget has consistently garnered a major component of the federal budget (3:35-42). Much of these funds has been devoted to new weapon system acquisition. As technology advances, the complexity of Air Force weapon systems has increased proportionately. The chief priority of the weapon systems acquisition community appears to be that of obtaining the highest level of performance possible, while incorporating the latest in technological sophistication. Unfortunately, such an objective does not come cheaply. The spiraling costs of new weapon systems have

drawn increased attention from all sectors of society concerned with the expanding defense budget. In particular, Congress has expressed concern over the often dramatic increases in total costs for weapon systems beyond original cost estimates. Such concern was evidenced in the U.S. Congress House of Representatives Committee on Government Operations report entitled "Inaccuracy of Department of Defense Weapons Acquisition Cost Estimates", published in 1979. This report explicitly detailed cost growth in defense systems for fiscal years 1969-1978 (3:82-91). Containing extensive cost growth within Air Force contracts is a very significant problem.

#### Research Question

Air Force contracts with industry have traditionally been guided by annual budget appropriations for the development of a particular weapon system. Cost estimates, which form the basis for the Air Force requests for appropriations, are often exceeded because of changes or modifications made to a contract during its execution. Information is needed on the relationships between modifications to an Air Force contract and the subsequent increases to contract cost. This investigation will answer the question, "For a recently completed Air Force development contract, what were the impacts of contract changes on cost growth?". By establishing and verifying such relationships, additional

information will be available to aid the program manager in better understanding the cost impact of contract changes. This understanding will enable managers to take corrective actions when identified cost growth causes are within their power to control.

### Investigative Questions

In order to answer the research question, the following investigative questions must first be considered:

1. What was the effect of contract changes to the contract structure?

a. Was there a significant cost difference between changes within the scope or outside the scope of the contract?

b. Did the page quantity of a statement of work (SOW) change have any correlation with cost?

c. Was contract type a factor in the cost of changes?

2. What was the effect of time on contract change?

a. Is there a significant cost difference between change orders and supplemental agreements?

b. Is there a significant cost difference between change orders and supplemental agreements involving SOW changes?

c. Is there a significant cost difference among change orders which required differing time spans for definition?

d. Is there a significant cost difference between contract changes with differing time spans for receipt of the cost proposal and the final approval date?

e. Is there a significant difference between the Not-To-Exceed (NTE) estimates and the final negotiated price of change orders?

f. Is there a relationship between the point of time in contract duration at which the change occurs and cost?

g. Is there a difference between contract change costs which occur before or after the Critical Design Review?

3. What was the effect of contract changes to the product delivery schedule?

a. Does the establishment of new hardware/software deliverables and schedule delays significantly impact cost versus other contract changes?

b. Does the establishment of new hardware/software deliverables and schedule delays significantly impact cost versus other contract changes involving SOW changes?

4. To what extent did design changes impact the contract?

a. Was the page quantity of an engineering change proposal a factor which affected cost?

b. Was there a significant cost difference between the lengths of the periods of performance for a contract change?

### Scope of Study

This study will examine the effects of contract change on cost growth within the full scale development contract (after contract restructure) for the Low Altitude Navigation and Targeting Infrared System for Night (LANTIRN) weapon system. The LANTIRN program is being managed under the Deputy for Reconnaissance, Strike and Electronic Warfare Division of Aeronautical Systems Division, Air Force Systems Command. LANTIRN is a navigation and targeting system designed to provide high-resolution infrared imagery and precision targeting functions for high-speed, low-altitude flight and air-to-ground weapon delivery over any terrain, at night, and in limited visibility conditions. The system is composed of a navigation pod and a targeting pod, and is being developed for Tactical Air Command to operate on the F-15E, F-16, and A-10 aircraft.

All findings and conclusions of this study are limited to the LANTIRN program, and should not be extrapolated to other weapon systems without further research. In addition, this study will focus only on cost growth attributed to modifications to the LANTIRN contract. Increases in cost due to other causes will be identified where possible, but not investigated.

## II. Literature Review

The purpose of this chapter is to review current literature which identifies numerous possible causes for the rapid growth in the costs of new weapon systems. These causes will be examined as applied to changes in contract type, prices, schedules, and system design. Prior to this discussion, various interpretations of the concept of cost growth and its measurement will be reviewed.

### Cost Growth

Cost growth is an elusive term with different meanings to different people. Some would define cost growth as "... the net increased cost to the Government of items or services procured or to be procured" (14:94). Others feel that cost growth amounts to the difference between the initial cost estimate for acquisition of a new weapon system and the final, actual cost of the system (15:37). Regardless of the precise definition, today's major weapon systems exhibit a consistent tendency to significantly exceed their original cost estimates. Such cost increases are undesirable because many Air Force, Department of Defense, and congressional decisions which affect the budget and defense priorities of the United States are based on cost estimates (18:116).

Concern over cost growth has generated interest from the very top of the government executive branch. In March

of 1982, President Reagan issued a memorandum to Secretary of Defense Weinberger requesting an investigation into Department of Defense (DOD) programs' cost growth. This action served to make the reduction of cost growth a priority, even in an era of increased defense budgets. President Reagan's action was not, however, the nation's first attention to cost growth. The term was first coined in 1969 by the Department of Defense, to describe total cost increases in defense programs (14:93-94).

The degree of cost growth within a program cannot be assessed without some means of measurement. Typically cost growth is measured by calculating how much greater the current estimate of the total system acquisition cost is than the initial development estimate (3:83). The development estimate is an estimate of the total system acquisition cost prior to systems development, whereas the current estimate includes all costs which have been incurred by the system at the date of the estimate plus a projection of the required costs to complete the system. If cost growth is encountered during the development of a major weapon system (greater than \$200 Million in RDT&E or \$1 Billion in Procurement costs), it is reported in the DOD Selected Acquisition Report (SAR), which is a yearly report to Congress. Seven categories of cost growth are displayed for the measurement of cost growth in these reports. These categories are economic changes, quantity changes, engineering changes,

support changes, schedule changes, estimating changes, and other changes.

Explanations for cost growth run the spectrum from inflation to poor management practices. Dr. Gardiner L. Tucker, a former Assistant Secretary of Defense for System Analysis, contends that the major contributors to cost growth are uncertainty, unrealistically low cost estimates, and inattention to proper system definition (14:94-95). A recent study identified four major categories of uncertainty within a program, those being target, technical, process, and internal program uncertainty. Target uncertainty refers to establishing cost, schedule, and performance goals. Technical uncertainty entails unpredictable technical problems. Internal uncertainty refers to managerial strategy. Process uncertainty is concerned with the availability of resources (18:18).

Another viewpoint asserts that low cost estimates are the major factor behind cost growth. An inclination to develop low cost estimates is the result of an environment which produces pronounced industry competition and military Service rivalries (3:39). As such, competition within and among military services for shares of the budget, and competition among contractors to submit the lowest (and therefore most desirable) cost bid, will perpetuate unrealistic initial estimates, and thus eventual cost growth (14:95).

An example serves to illustrate this downward bias in cost estimates. By the end of fiscal year 1978, current estimates of total program cost growth for all major DOD weapon systems acquired since 1969 reached \$215 billion. Of this \$215 billion, 57 percent was for the Navy, 25 percent for the Air Force, and 18 percent for the Army. The original development estimates for these same systems was \$150 billion, which translates into a cost growth of nearly 45 percent (3:83-84).

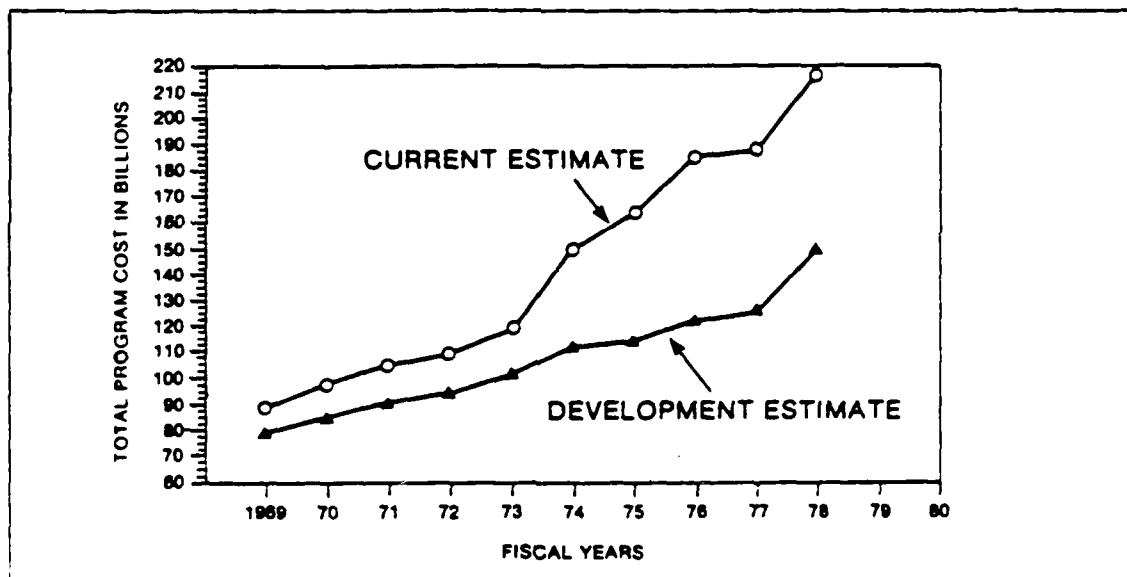


Figure 2.1 Dollar Comparison of Development Estimates and Current Estimates of Defense Systems for Fiscal Years 1969-1978 (Adapted from 3:84)

Figure 2.1 displays the trend in cost growth for all DOD major weapon systems from 1969 through 1978 by comparing the initial development estimate and current total program

cost estimate. The difference between development estimates and current estimates has increased from \$10 billion in 1969 to approximately \$65 billion in 1978. This trend can also be displayed on a percent basis.

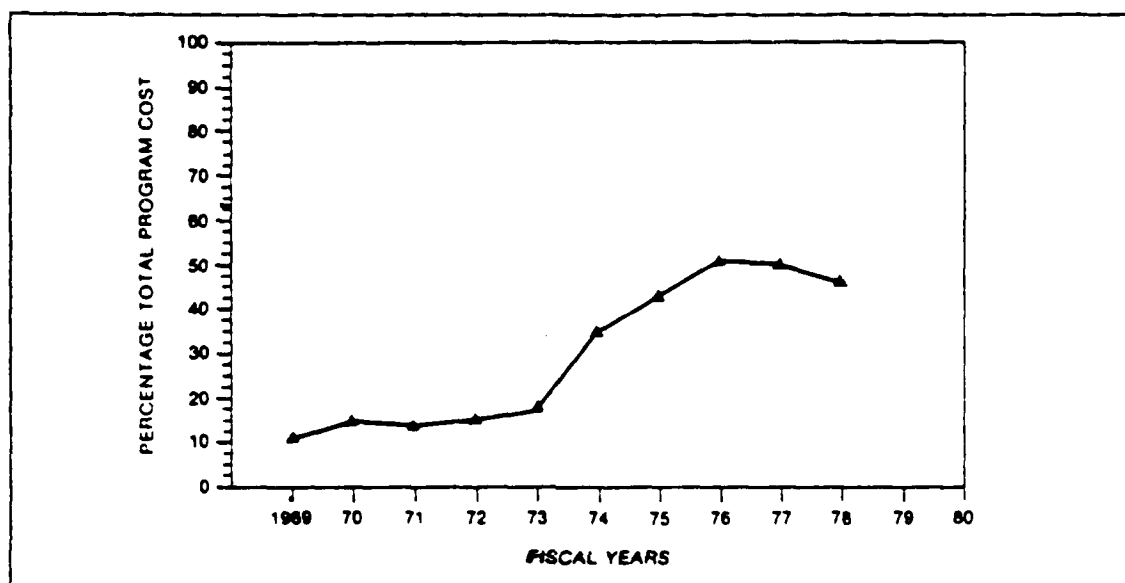


Figure 2.2 Percentage Cost Growth of Defense Systems for Fiscal Years 1969-1978  
(Adapted from 3:85)

Figure 2.2 shows a gradual increase in the difference between current estimates and development estimates, ranging from 12 percent in 1969 to 17 percent in 1973. After 1973, the graph reveals a sharp increase with periods where current estimates exceeded development estimates by greater than 50 percent. High levels of inflation have been suggested as a significant contributor to cost growth occurring after 1973. Another pattern extracted from this data

is that cost estimates tend to escalate well beyond the levels originally anticipated as a program progresses through the acquisition cycle (3:83-84).

Services	Economic	Quantity	Engineering	Support	Schedule	Estimating	Other
Army	1	2	7	5	4	3	6
Navy	2	1	5	6	3	4	7
Air Force	1	2	5	4	3	7	6
DOD	1	2	6	5	3	4	7

Figure 2.3 Ranking of the Relative Contribution of Seven Major Categories Toward Cost Growth, Fiscal Year 1979  
(Adapted from 3:87)

The effects of cost growth can also be classified by its causes. Figure 2.3 presents a ranking of the seven major DOD cost growth categories for the Services, as compiled from data reported in the U.S. Congress. Much similarity exists within the ranking of these cost growth causes among the Services. The impact of inflation accounts for more cost growth than any other identified factor, amounting to about 30 percent of the total. Quantity changes ranked second, followed by schedule changes and cost estimating changes (3:87-88).

Other commonly identified causes for cost growth include budget instability, low production rates, lack of interservice standardization, inflation, excessive documentation, and poor subcontractor control (5:24;14:100). These factors have led some to the conclusion that cost growth will occur "...simply due to the market environment in which systems are procured coupled with the great uncertainties and risks that accompany the development of new weapon systems" (3:82). Finally, opinion exists that many of the conventionally identified causes of cost growth are nothing more than symptoms of more critical problems in the acquisition process itself (5:24). To better understand the impact of the cost growth problem, these causes can be related to their effect on different contract changes which occur in the acquisition of a typical weapon system.

#### Contract Type

The heart of the acquisition process is the written contract between industry and the government for the development of a weapon system. The contract specifies what work is to be performed for what remuneration. Contracts can be categorized into the two broad areas of cost contracts and fixed price contracts. Under cost type contracts, the government reimburses the contractor those costs which are authorized by a contracting officer as being allowable. Such a contract is usually employed on projects with a high

degree of technical risk and uncertainty. Fixed price contracts establish a firm price agreement, and the government is not liable for any additional cost. This type of contract is used when there is little performance, cost, or schedule uncertainty (9:20).

Contracts may also be classified as either a completion or a term contract. With a completion contract, the contractor is required to deliver a specified end product. A completion contract is usually of fixed price type. A term contract requires only that a specified time length of effort is applied, utilizing certain skill levels and facilities. In other words, a contractor is only legally accountable for applying a "best effort" to accomplish the objectives of the contract. Term contracts are generally of cost reimbursement type (9:19-20).

Contracts may also be modified to include incentive provisions. Many incentive contracts are set up in an effort to contain cost growth (9:21). One study prepared for the United States Army Procurement Research office analyzed the average cost growth per contract type for 100 major Army programs. The study found an average of 52.7% cost growth on firm fixed price contracts, 10.9% cost growth on fixed price incentive contracts, 117.5% cost growth on cost plus incentive fee contracts, and 50.2% cost growth on cost plus fixed fee contracts. Common causes for cost growth among the different contract types included

quantity changes and engineering change proposals (18:126-127).

The use of incentives must be scrutinized to ensure they are not counterproductive. Concern exists that the DOD has numerous contract incentives, all developed in isolation, which are not always understood nor congruous. These include design-to-cost goals, reliability incentives, award fees, potential quality incentives, and cost-plus incentive contracts. Until guidance is issued on the systematic use and interrelationship of incentives, discretion must be exercised (11:22).

One innovation to the procedure of administering contracts that is gaining in popularity is the concept of multiyear procurement. In multiyear procurement, instead of individually funding contracts for only one years' production requirements, several years of production quantities are funded by a single contract. By following such a practice, the government can capitalize on cost savings inherent in buying in large quantities. Also, defense contractors, upon recognizing the commitment of the government, are more inclined to make capital investments that reduce long range costs and strengthen the industrial base (17:23-25). As should now be apparent, the type of defense contract selected provides much latitude for potential cost control.

Contract composition is also being reviewed as a channel for reducing costs. This is evidenced by the

Streamlining Initiative, authorized by the Deputy Secretary of Defense in January 1984. The purpose of this initiative is to avoid costly and unnecessary requirements sometimes imposed by defense contracts (10:7). Savings can then be realized by the elimination of untailored and accidentally referenced application of military standards and/or specifications. Also, contracts should specify results required rather than listing detailed procedures. The basic premise behind the streamlining initiative is that the cost-effective application of requirements should be an integral part of the design and development process (10:6-9). A reduction in unnecessary and counterproductive requirements should result in reduced costs and lower cost overruns.

An even more encompassing approach to reducing costs involving defense contracts entails improving the productivity of the acquisition environment. This was the thrust of the Acquisition Improvement Program, authorized by then Deputy Secretary of Defense Frank Carlucci in April 1981 (3:81). The program identified 32 initiatives designed to shorten and simplify the acquisition process, and to control costs. Over the years, the Carlucci initiatives have undergone change, and former Deputy Secretary of Defense Paul Thayer decided to place priority on the six management areas that provided the greatest potential payback. These areas included program stability, multiyear procurement, economic production rates, realistic budgeting, support and readiness, and competition (11:16).

### Contract Schedule and Price

Another aspect of weapon systems acquisition influential in altering costs is that of changes to contract prices and schedules. Due to the nature of research and development activity, any delay in overall contract schedule usually results in increased costs. These costs derive from "...rising overhead expenses and from failure of producers to utilize optimally their productive facilities" (3:88). Another view states that due to outside pressures, a manager must often proceed with full commitment to a project on the basis of partial information. As such, unforeseeable conditions inevitably occur which result in schedule delays (15:38,41).

Price changes in contracts also have a direct impact on weapon system cost. Many diverse causes can necessitate price changes, such as drastic changes in the economy. During the 1970's and 1980's the United States economy often fluctuated, as reflected by major variations in the prices of oil and gold. To accomodate such changes, most defense contracts now include escalation adjustment clauses, which allow economic conditions to influence costs. Price changes may also occur due to variance in a defense contractor's workload structure. If other projects the contractor is working are unexpectedly cancelled, overhead rates on all contracts may be increased (15:42-43). Such arguments reveal that changes in contract prices and schedule are indeed a prominent factor in cases of cost growth.

## System Design

The design of a weapon system is the vehicle which transforms a mission need into an operational system. Since all work is planned to implement a particular design, any changes in that design mean increases in cost. Proper design work is crucial to controlling post-acquisition costs, since operation and support costs typically double those of acquiring the system. To contain these costs, life cycle cost considerations must be integrated early in the system design phase (7:36).

Even with careful, detailed attention and planning for system design, technical risk can at best only be reduced (9:41). Through a combination of rapid technological advancement and political pressures, design changes are bound to occur at some point in system development. In addition, one must be alert for the addition of unrealistic or unnecessary requirements, or "gold-plating" (15:3,43). One viable alternative for minimizing design change is prototype fabrication and testing, which allows the buyer to test a design before fully committing to it (18:122).

A related aspect of weapon system acquisition that affects design is program stability. Many factors can contribute to an acquisition program's instability, such as irregular funding, poorly defined requirements, political issues, changes in military guidance, and changes in the enemy threat (4:31;16:19). Any of these factors can neces-

sitate a change in system design. One recommended procedure for improving program stability is program baselining. A program baseline is a thorough description of a weapon system program in terms of technical performance, schedule, and logistics requirements, as agreed upon by all participants in the acquisition process (16:15). Other activities to insure program stability include anticipation of future needs, careful planning and program definition, and appropriate contracting techniques (15:45).

A system design must also incorporate the state of available manufacturing technology, if production costs are to be minimized. This principle is reflected in the concept of the manufacturing yield. A manufacturing yield is defined as the ratio of the number of acceptable items produced the first time through a process to the number that entered production (12:17). If this ratio is too low, financial loss will occur through scrap and rework costs. To reduce these costs requires a stable design and the application of adequate manufacturing process controls.

Research has documented the poor manufacturing yields and high rates of rework at some U.S. defense production plants. A 1982 study of aerospace productivity revealed that retest and rework sometimes consume up to 40 percent of a plant's productive capacity (12:11). Another study found that yields during some defense production start-ups are as low as 5 to 10 percent. Such research further highlights

the need for current manufacturing technology to be incorporated into stable system design.

#### Summary

This section has illustrated that the problem of cost growth in weapon system acquisition can afflict the vast majority of defense programs, in many ways. Of the numerous explanations of the causes for cost growth that have been offered, the majority involve changes in contract type, schedules, prices or system design. Suggestions to improve cost control include the use of multiyear procurement, and increasing program stability. Though possible solutions abound, there appears to be no universal panacea to the problem of cost growth, possibly due to the complexity of its causes. Continued analysis and application of validated improvements to the acquisition process may be the only true method of reducing cost growth.

### III. Methodology

This chapter presents the methodology that was pursued to answer the research and investigative questions proposed in Chapter I of this study. The data source, data collection plan, and statistical tests which were used to analyze the data are described.

#### Data Source

The LANTIRN program office is in the Deputy for Reconnaissance, Strike, and Electronic Warfare Division of Aeronautical Systems Division, located at Wright- Patterson AFB. All contractual data on the program were maintained by the contracts functional office of the LANTIRN SPO, identified by the office symbol RWNK. The LANTIRN Full Scale Engineering Development (FSED) contract (assigned Contract #F33657-80-C-0441) was issued by RWNK on September 19, 1980, with the Martin-Marietta Corporation of Orlando, Florida serving as the prime contractor. The contract consisted of both firm fixed price and cost plus components. Following contract award, Martin-Marietta experienced difficulties in subcontractor management, and also encountered major technical problems which resulted in substantial cost growth and schedule slippages. In June 1981, the Air Force directed Martin-Marietta to prepare a restructured FSD proposal incorporating risk reduction

efforts, and trade-offs to achieve minimum cost. On February 2, 1983 a complete restructure of the LANTIRN FSED contract was incorporated. For purposes of this study, only contract changes executed after the program restructure are considered relevant.

All changes to the LANTIRN contract are documented on an AFSC form 702 - Amendment of Solicitation/Modification of Contract. All contract modification documentation is maintained by the ASD contract files office (office symbol ASD/PMAS, Bldg 11), with copies held by RWNK.

#### Data Collection Plan

The data were collected by performing a record analysis, a form of nonbehavioral observation (8:176). Upon approval of the study by the RWNK office chief, data collection was begun by reviewing copies of all AFSC form 702s available subsequent to the program restructure. Any contract modifications not available through the RWNK office were obtained from the ASD contract files office. The LANTIRN FSED contract had not reached full completion at the time of this study, therefore only contract modifications which had received final approval prior to December 31, 1985 are included as data.

To facilitate data analysis, the contract modifications were grouped into four broad categories. A listing of these categories and their requisite criteria are recorded in Table 3.1.

TABLE 3.1

Classifications of Contract Modifications

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Category I - Statement of Work (SOW) changes, No Delivery Impact

Criteria: Additions/Changes to SOW (Section J of contract) documented on AFSC form 702, no other modifications

Samples: New work in form of Studies, Analyses, etc.

Category II - SOW changes, Delivery Impact

Criteria: SOW change documented on AFSC form 702, change to a non-data end item delivery date documented on AFSC form 706, Supplies Schedule Data

Samples: Design changes, Engineering Change Proposals (ECP), etc.

Category III - SOW changes, New Deliverables

Criteria: SOW changes documented on AFSC form 702, new line items documented on AFSC form 705, Supplies Line Item Data, and delivery dates established for new deliverables on AFSC form 706, Supplies Schedule Data

Samples: New work resulting in new hardware or software deliverables

Category IV - Contract changes, No SOW impact

Criteria: Change to some section of contract not affecting SOW, documented by AFSC form 702

Samples: Deviations/Waivers, GFE repair, etc.

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For each contract change, additional data recordings were also made. This information includes the cost of the change, the date of the change proposal, the final approval date of the change, the page quantity of the SOW involved (if applicable), the period of performance proposed for the change, and other miscellaneous data. Contract changes implemented to incrementally fund the contract, administrative changes, and changes involving the classified HAVE LIGHT program were excluded from study. In addition, all cost figures involved were adjusted to 1986 dollars (2;reference appendices A-E).

Table 3.2 provides the specific variables to be analyzed for each investigative question. Each variable will be ultimately related to changes in contract cost.

TABLE 3.2

## Data Analysis Used to Answer Research Questions

Research Question	Variables	Analysis
1a	In-scope vs. out of scope changes	MANN-WHITNEY
1b	Page quantity of Sow changes vs. cost	KRUSKAL-WALLIS
1c	Cost plus vs. fixed price changes	MANN-WHITNEY
2a	Change order vs. supplemental agrmt	MANN-WHITNEY
2b	Change order vs. supplemental agrmt involving Sow change	MANUAL
2c	Time spans elapsed to definitize a change order vs. cost	KRUSKAL-WALLIS
2d	Receipt of cost proposal vs. final approval date	KRUSKAL-WALLIS
2e	NTE vs. final change order cost	MANN-WHITNEY
2f	Point in time of contract change vs. cost	KRUSKAL-WALLIS
2g	Changes before vs. after CDR	MANUAL
3a	Delivery schedule additions and delays vs. other changes	MANN-WHITNEY
3b	Delivery schedule additions and delays vs. other changes involving SOW modifications	MANN-WHITNEY
4a	ECP page length vs. cost	KRUSKAL-WALLIS
4b	Length of period of performance vs. cost	MANN-WHITNEY

## Data Analysis

The SPSSx subroutines MANN-WHITNEY and KRUSKAL-WALLIS were employed for initial data analysis. These subroutines perform nonparametric tests which determine whether or not there are differences in true averages among two or more populations. Whenever sample sizes are small, or populations may not be normally distributed, nonparametric statistical procedures which do not require assumptions about the shapes of underlying distributions are appropriate. The factor under study, which is the cost of contract changes expressed in dollars, serves as the dependent variable. The different populations, or levels of the factor, are the independent variables. Data employed in this study satisfy the analysis requirement that the dependent variable must be expressed as at least ordinal level data, and that the independent variable must be expressed as at least nominal level data.

The following hypothesis was tested:

$H_0$ : There is no difference in the costs of contract changes among the populations of the independent variable (sample means are equal)

$H_a$ : There is a statistically significant difference in the costs of contract changes among the different populations (at least two of the sample means are not equal)

The MANN-WHITNEY subroutine first combined and ranked the observations for both samples from smallest to largest. The statistic for testing the hypothesis that the two dis-

tributions are equal is the sum of the ranks for each of the two groups. If the two groups have the same distribution, their sample distribution of ranks should be similar. Scores from the test are transformed to a standard normal deviate (Z), and a probability level is computed. If the Z probability statistic was less than the 0.05 level of significance, the null hypothesis was rejected. Rejection of the null hypothesis indicated that a statistically significant difference existed among the contract change cost means for the two populations.

The KRUSKAL-WALLIS subroutine performs a procedure similar to that used in the Mann-Whitney test, and was used for analysis involving more than two groups. All the cases from the groups were combined and ranked, with average ranks being assigned in the case of ties. For each group, the ranks were summed, and the Kruskal-Wallis H statistic was computed from these sums. The H statistic has approximately a chi-square distribution under the hypothesis that the subject groups have the same distribution. If the chi-square probability statistics was less than the 0.05 level of significance, the null hypothesis was rejected. Rejection of the null hypothesis would indicate that a statistically significant difference existed among the contract change cost means for the subject groups. Multiple comparisons analysis would then be required to determine which groups differ significantly from one another (6:355;13:111).

#### IV. Findings and Analysis

This chapter presents the descriptive statistics and analysis for the data collected from the LANTIRN contract files. Each of the 13 investigative questions is analyzed separately. Hypotheses that were tested are identified in conjunction with the statistical procedure used to test the hypothesis. The findings are expanded to include inferences that could have important implications for acquisition management, even though they cannot be explicitly supported by statistical analysis.

##### Presentation of Findings

##### Investigative Question 1a

**Was there a significant cost difference between changes within the scope or outside the scope of the contract?**

For this investigative question, contract changes were grouped into the categories of either being within the scope or outside of the scope of the contract. If there was no Statement of Work (SOW) addition or change, then the contract change was considered within the scope of the contract (Group 1). If the contract modification involved an addition or change to the SOW (Section J of the contract) as

documented by AFSC form 702, then the contract change was considered outside of the scope of the contract (Group 2).

TABLE 4.1

Descriptive Statistics for Investigative Question 1a

Group	Count	Mean Cost	Standard Deviation	Standard Error	95 Pct Conf Int for Mean
Grp 1	25	1084	3694	739	-441 to 2608
Grp 2	12	10873466	21743560	6276825	-2941730 to 24688663
Total	37	3527262	13079942	2150329	-833808 to 7888331

Group	Minimum Cost	Maximum Cost
Grp 1	0	17870
Grp 2	200984	69167180
Total	0	69167180

A MANN-WHITNEY test was conducted on this population of contract changes, with the type of contract change as the independent variable and the cost of the contract change as the dependent variable. Contract changes were classified as

being either within the scope or outside of the scope of the contract. Results of the test are displayed in Table 4.2.

TABLE 4.2

MANN-WHITNEY Test Results for Investigative Question 1a

Mean Cost	Rank	Cases	Group	Corrected for Ties	
				Z	2-Tailed P
1084	13.00	25	Inscope	-5.3827	0.0000
10873466	31.50	12	Outscope		

The following null hypothesis was tested:

$H_0$ : There is no difference in the mean cost of contract changes among changes within the scope or outside of the scope of the contract.

$H_a$ : There is a statistically significant difference in the mean cost of contract changes among changes within the scope or outside of the scope of the contract.

The null hypothesis was rejected for the subject population of contract changes at a significance level of 0.050. This research concludes that for the LANTIRN FSED contract, whether a contract modification was considered within the scope or outside of the scope of the contract played a major role in the magnitude of cost addition to the

contract. The relatively large sample sizes, very small p-value, and extreme difference in the mean costs tend to reinforce this view. Of the 37 contract changes recorded, approximately 32% were changes considered outside of the scope of the contract. The high mean cost for these contract modifications accounts for a large portion of the cost increase in the LANTIRN FSED contract.

Investigative Question 1b

Did the page quantity of a statement of work (SOW) have any correlation with cost?

This investigative question involved only contract changes which contained SOW changes or additions. Specifically, the contract changes were categorized by the length of the SOW additions. The first category contains SOW additions under 3 pages in length (Group 1). Next are SOW additions between 3-5 pages in length (Group 2). The final category contains SOW changes over 5 pages in length (Group 3). SOW changes and additions were identified by modification to Section J of the contract, as documented by AFSC form 702.

TABLE 4.3

## Descriptive Statistics for Investigative Question 1b

Group	Count	Mean Cost	Standard Deviation	Standard Error	95 Pct Conf Int for Mean
Grp 1	3	719327	1048088	605114	-1884296 to 3322951
Grp 2	6	217338	3042335	1242028	-1019348 to 53660024
Grp 3	3	37362382	34226926	19760925	-47662949 to 122387713
Total	12	10607096	21865395	6311996	-3285511 to 24499703

Group	Minimum Cost	Maximum Cost
Grp 1	0	1921852
Grp 2	200984	7984135
Grp 3	1141923	69167180
Total	0	69167130

A KRUSKAL-WALLIS test was performed on contract changes involving SOW additions, with the page quantity of the subject SOW as the independent variable and the cost of the accompanying contract change as the dependent variable. Contract changes involving SOW additions were grouped by

those SOWs under 3 pages in length, between 3-5 pages, and over 5 pages in length. Results of the test are displayed in Table 4.4.

TABLE 4.4

KRUSKAL-WALLIS Test Results for Investigative Question 1b

Mean Cost	Rank	Cases	Group	Corrected for Ties Chi-Square	Significance
719327	4.00	3	3 pages	4.3846	.111
2173338	6.00	6	3-5 pages		
37362382	10.00	3	over 5 pages		

The following null hypothesis was tested:

$H_0$ : There is no difference in the mean cost of contract changes involving SOWs of differing page quantities.

$H_a$ : There is a statistically significant difference in mean cost of contract changes involving SOWs of differing page quantities.

The null hypothesis was not rejected for this population of contract changes at a significance level of .05. This research concludes that for the LANTIRN FSED contract there was no significant difference among the cost of contract changes involving SOWs of different page

lengths. A review of mean costs for the three groups does, however, show a steady increase as the length of the SOWs increase. The small sample sizes involved and the variability in the data could account for the lack of statistical significance in the results. Therefore the page length of a SOW for a contract modification may indeed be correlated with the cost of the contract change, the relationship being that the greater the length of the SOW, the greater the cost of the contract modification.

#### Investigative Question 1c

**Was contract type a factor in the cost of changes?**

The LANTIRN Full Scale Development (FSD) contract is structured such that it contains both firm fixed price and cost plus components for the various work efforts. This investigative question categorizes contract changes by the type of contract involved. Group 1 contains contract changes which affect the cost plus component of the contract, and Group 2 contains contract changes which affect the fixed price component of the contract.

TABLE 4.5

## Descriptive Statistics for Investigative Question 1c

Group	Count	Mean Cost	Standard Deviation	Standard Error	95 Pct Conf Int for Mean
Grp 1	3	1610134	412844	238355	584562 to 2635706
Grp 2	25	6019419	15593954	3118790	-417448 to 12456287
Total	28	5546996	14767997	2790889	-179435 to 11273427

Group	Minimum Cost	Maximum Cost
Grp 1	1141923	1921852
Grp 2	1567	69167180
Total	1567	69167180

A MANN-WHITNEY test was conducted on the relevant contract changes, with the type of contract to which the change was made as the independent variable and the cost of the contract change as the dependent variable. Contract changes were classified as to whether they modified the firm fixed price or the cost plus component of the LANTIRN contract. Results of the test are recorded in Table 4.6.

TABLE 4.6

MANN-WHITNEY Test Results for Investigative Question 1c

Mean Cost	Rank	Cases	Group	Corrected for Ties Z	2-Tailed P
1610134	16.67	3	Cost-Plus	-0.6734	0.6291
6019419	14.24	25	Fixed-Price		

The following null hypothesis was tested:

$H_0$ : There is no difference in the mean cost of contract changes between those changes affiliated with the fixed-price component of the contract and the cost-plus component.

$H_a$ : There is a statistically significant difference in the mean cost of contract changes between those changes affiliated with the fixed-price component

The null hypothesis was not rejected for the involved groups of contract changes at a significance level of 0.050. This research concludes that for the LANTIRN FSED contract there was no significant difference in the mean contract change cost for changes to either the firm-fixed price or cost-plus components of the contract. In review of the data, it is noted that there were only three cases of changes to the cost-plus component of the contract, as opposed to

25 cases for the firm-fixed price component. The small sample size for the cost-plus contract changes may have resulted in a more deflated significance value than if the sample size were closer to that encountered with the firm-fixed price contract changes. Also, the mean contract change cost for the fixed-price changes is approximately 4.4 million dollars greater than that for the cost-plus changes. Thus, the greatest number of contract changes were to the component of the contract (fixed-price) which had the highest mean contract change cost. Although not statistically different, the data suggest that changes to the firm-fixed price component of the contract are more costly on average than changes to the cost-plus contract component.

#### Investigative Question 2a

**Is there a significant cost difference between change orders and supplemental agreements?**

This investigative question categorizes contract changes by the process used to formalize the change. If a contractor is given authorization to begin a new work effort prior to the cost of the effort being fully negotiated (based on a not-to-exceed estimate), this action is known as a change order. A final cost for the change order is then negotiated at a later date and incorporated as a supplemental agreement. If the cost of a new work effort is fully negotiated prior to the contractor beginning the actual

work, then the modification is referred to as a supplemental agreement. Group 1 contains contract changes authorized by change order and Group 2 contains contract changes authorized by supplemental agreement.

TABLE 4.7

Descriptive Statistics for Investigative Question 2a

Group	Count	Mean Cost	Standard Deviation	Standard Error	95 Pct Conf Int for Mean
Grp 1	10	8678170	21388441	6763619	-6622191 to 23978531
Grp 2	28	896	3495	660	-459 to 2251
Total	38	2284389	11236998	1822882	-1409120 to 5977899

Group	Minimum Cost	Maximum Cost
Grp 1	200984	69167180
Grp 2	0	17870
Total	0	69167130

A MANN-WHITNEY test was performed on the contract modifications with the type of contract change as the independent variable and the cost of the contract change as the

dependent variable. Contract changes were grouped by the process used to formalize the change, the two processes being change orders and supplemental agreements. For change orders the final, fully negotiated supplemental agreement cost is utilized and not the not-to-exceed (NTE) estimate. Results of the test are displayed in Table 4.8.

TABLE 4.8  
MANN-WHITNEY Test Results for Investigative Question 2a

Mean Cost	Rank	Cases	Group	Corrected for Ties	
				Z	2-Tailed P
8678169	33.50	17	Change Orders	-5.3649	0.0000
896	14.50	28	Supp Agreements		

The following null hypothesis was tested:

$H_0$ : There is no difference in the mean cost of contract changes among change orders and supplemental agreements.

$H_a$ : There is a statistically significant difference in the mean cost of contract changes among change orders and supplemental agreements.

The null hypothesis was rejected for the involved groups of contract changes at a significance level of 0.053.

This research concludes that for the LANTIRN FSED contract there was a significant difference between the mean cost of change orders and supplemental agreements, with change orders being much more costly. Change orders also comprised the majority of contract changes involving changes to the SOW (out-of scope changes), and consequently the more major work efforts. Out-of-scope changes had previously been demonstrated to be more costly than in-scope changes (reference investigative question 1a). Many of the same contract changes which were included in the out-of the scope of the contract category also reappear in the change order category (reference appendices G and J). It must also be noted that many of the supplemental agreement contract changes were within the scope of the contract and were executed at no cost to the government (reference appendix J).

#### Investigative Question 2b

**Is there a significant cost difference between change orders and supplemental agreements involving SOW changes?**

Contract change classifications for this investigative question were limited to those contract changes involving additions or changes to the contract SOW. These changes were then further subdivided by whether they were authorized by change order or supplemental agreement. Group 1 contains SOW contract changes authorized by change order and Group 2

contains SOW contract changes authorized by supplemental agreement.

TABLE 4.9  
Descriptive Statistics for Investigative Question 2b

Group	Count	Mean Cost	Standard Deviation	Standard Error	95 Pct Conf Int for Mean
Grp 1	10	8678169	2138441	6763619	-6622191 to 23978531
Grp 2	1	0	0	0	0 to 0

Group	Minimum Cost	Maximum Cost
Grp 1	200934	69167180
Grp 2	0	0
Total	0	69167180

Review of the LANTIRN FSED contract files revealed that all contract modifications involving SOW changes were accomplished by change order. As such, no comparisons could be made between supplemental agreements and change orders which both involved SOW changes. Investigative Question 1a has previously demonstrated that contract modifications involving SOW changes (out-of-scope) are significantly more

costly than changes within the scope of the contract. Investigative Question 2a demonstrated that change orders are on average more costly than supplemental agreements. Without supplemental agreements involving SOW changes available for comparison, the exact relationship between change orders, out-of-scope contract changes, and in-scope contract changes cannot be determined. Specifically, it cannot be determined whether out-of scope changes are more costly than in-scope changes because they involve SOW alterations, because they were implemented by change order, or because of some combination of the two.

Investigative Question 2c

Is there a significant cost difference among change orders which required differing time spans for definition?

After a change order is authorized, a final cost for the work effort involved must be negotiated and incorporated as a supplemental agreement. This investigative question examines the period of time elapsed between authorization of a change order and incorporation of a fully negotiated cost via supplemental agreement. Group 1 contains change orders fully negotiated in under 5 months. Group 2 contains change orders fully negotiated within 5-6 months, and Group 3 contains change orders fully negotiated in excess of 6 months.

TABLE 4.10

## Descriptive Statistics for Investigative Question 2c

Group	Count	Mean Cost	Standard Deviation	Standard Error	95 Pct Conf Int for Mean
Grp 1	2	218557	24852	17573	-4729 to 441843
Grp 2	3	2051203	980376	566021	-384214 to 4486620
Grp 3	4	2437304	3709004	1854502	-3464464 to 8339071
Total	9	1815549	2500168	833389	-10629 to 3737346

Group	Minimum Cost	Maximum Cost
Grp 1	200934	236130
Grp 2	1141923	3089834
Grp 3	303197	7984185
Total	200934	7984185

A KRUSKAL-WALLIS test was conducted on the change order population, with the time span required for change order definitization serving as the independent variable and the cost of the change order (contract change) as the dependent variable. The change orders were grouped as re-

quiring either under 5 months, between 5-6 months, or over 6 months for final cost negotiation and agreement. Results of the test are displayed in Table 4.11.

TABLE 4.11

KRUSKAL-WALLIS Test Results for Investigative Question 2c

Mean Cost	Rank	Cases	Group	Corrected for Ties Chi-Square	Significance
218557	1.50	2	under 5 mo's	4.9000	0.0863
2051203	7.00	3	5-6 months		
2437304	5.25	4	over 6 mo's		

The following null hypothesis was tested:

$H_0$ : There is no difference between the mean cost of contract changes involving change orders with differing time spans required for definitization.

$H_a$ : There is a statistically significant difference in the mean cost of contract changes involving change orders with differing time spans required for definitization.

The null hypothesis was not rejected for the three groupings of change orders at a significance level of 0.050. This research concludes that for the LANTIRN FSED contract, there is no significant difference between the contract change costs for change orders which required differing time

spans for definitization. The significance level achieved, however, may be understated due to the small sample sizes involved. Further supporting evidence is provided by the magnitude of difference in means between Group 1 and Groups 2 and 3 (Reference Table 5.5). Thus the possibility exists that there may be correlation between cost and the length of time required for change order definitization, with the trend being that the greater the cost, the greater the length of time needed to definitize the change.

#### Investigative Question 2d

Is there a significant cost difference between contract changes with differing time spans for receipt of the cost proposal and the final approval date?

Prior to the initiation of new work, the SPO must receive some type of cost estimate from the contractor before final authorization can be given. This investigative question examines the length of time elapsed between receipt of a cost proposal from the contractor and approval from the SPO to initiate the work effort (either by change order or supplemental agreement). Group 1 contains contract changes which required less than 3 months to negotiate; Group 2 contains contract changes which required between 3-5 months to negotiate; and Group 3 contains contract changes which required more than 5 months to negotiate.

TABLE 4.12

## Descriptive Statistics for Investigative Question 2d

Group	Count	Mean Cost	Standard Deviation	Standard Error	95 Pct Conf Int for Mean
Grp 1	3	23763339	39330293	22707355	-73939599 to 121466276
Grp 2	4	540712	413978	206989	-118010 to 1199433
Grp 3	4	3812672	2962345	1481172	-901011 to 8526355
Total	11	8063959	20392859	6148678	-5636146 to 21764064

Group	Minimum Cost	Maximum Cost
Grp 1	200984	69167180
Grp 2	236130	1141923
Grp 3	980236	7984185

A KRUSKAL-WALLIS test was performed on the relevant population of contract changes, with contract changes involving cost proposals as the independent variable and the cost of the contract change as the dependent variable. Contract changes involving cost proposals were grouped by those requiring under 3 months, between 3-5 months, or over

5 months to obtain final approval. Results of the test are displayed in Table 4.13.

TABLE 4.13  
KRUSKAL-WALLIS Test Results for Investigative Question 2d

Mean Cost	Rank	Cases	Group	Corrected for Ties Chi-Square	Significance
23763339	6.33	3	3 months	3.3258	0.1896
540712	3.75	4	3-5 months		
3812672	8.00	4	over 5 months		

The following null hypothesis was tested:

$H_0$ : There is no difference in the mean cost of contract changes involving cost proposals with differing time spans for receipt of the cost proposal and the final approval date.

$H_a$ : There is a statistically significant difference in the mean cost of contract changes involving cost proposals with differing time spans for receipt of the cost proposal and the final approval date.

The null hypothesis was not rejected for the subject group of contract changes at a significance level of 0.050. This research concludes that for the LANTIRN FSED contract

there was no significant difference in the mean contract change cost for changes involving cost proposals with differing time spans to obtain final approval. The small sample sizes involved may be a contributing factor to the achieved level of significance. Even with small sample sizes taken into account, there does not appear to be correlation between time spans for cost proposal final approval and cost.

Investigative Question 2e

Is there a significant difference between the Not-To-Exceed (NTE) estimates and the final negotiated price of change orders?

Change orders are issued based on a not-to-exceed estimate (NTE), in lieu of a fully negotiated cost proposal. At some later date, a complete cost proposal for the work effort must be negotiated and formalized as a supplemental agreement. The final cost for the work effort may not exceed the NTE; however, a lower cost can be negotiated. For this investigative question, contract changes implemented by change order are grouped and examined. Group 1 contains the NTE costs for the change orders and Group 2 contains the final negotiated supplemental agreement cost.

TABLE 4.14

## Descriptive Statistics for Investigative Question 2e

Group	Count	Mean Cost	Standard Deviation	Standard Error	95 Pct Conf Int for Mean
Grp 1	9	2415937	3449066	1149355	-234479 to 5066352
Grp 2	9	1315549	2500168	833389	-106248 to 3737346
Total	18	2115743	2938007	692495	654706 to 3576779

Group	Minimum Cost	Maximum Cost
Grp 1	293144	11187518
Grp 2	200984	7984135
Total	200984	11187518

A MANN-WHITNEY test was performed on the population of change orders, with the stage of the change order as the independent variable and the cost of the contract change as the dependent variable. The change orders were classified by their NTE's and final negotiated prices. Results of the test are displayed in Table 4.15.

TABLE 4.15

MANN-WHITNEY Test Results for Investigative Question 2e

Mean Cost	Rank	Cases	Group	Corrected for Ties Z	2-Tailed P
2415937	10.44	9	NTE	-0.7506	0.4529
1315549	8.56	9	Final Cost		

The following null hypothesis was tested:

$H_0$ : There is no difference in the mean cost between NTE estimates and the final negotiated price for change orders?

$H_a$ : There is a statistically significant difference in the mean cost between NTE estimates and the final negotiated price for change orders.

The null hypothesis was not rejected for the two stages of change orders at a significance level of 0.050. This research concludes that for the LANTIRN FSED contract there was no significant difference in the mean cost of NTE estimates and the final approved cost for change orders. This finding indicates that even though the contractor delivers a NTE estimate prior to change order approval, this "estimate" will likely not differ significantly from the final negotiated cost. Since a contractor will typically,

by definition of a NTE, provide a very conservative cost estimate, the practice of issuing change orders would not appear to be the most cost efficient method for implementing contract changes.

Investigative Question 2f

Is there a relationship between the point of time in contract duration at which the change occurs and cost?

The LANTIRN FSED contract was restructured in February 1983, and data for this study was collected through December 1986. For this investigative question, contract changes are grouped by the fiscal year in which they were executed. If a contract change was retroactive, then the effective date serves as the date of execution. Group 1 contains contract changes executed in 1982; Group 2 contains contract changes executed in 1983; Group 3 contains contract changes executed in 1984; and Group 4 contains contract changes which were executed in 1985.

TABLE 4.16

## Descriptive Statistics for Investigative Question 2f

Group	Count	Mean Cost	Standard Deviation	Standard Error	95 Pct Conf Int for Mean
Grp 1	3	189639	328464	189639	-626327 to 1005597
Grp 2	15	5845392	17755949	4584566	-3987525 to 15678308
Grp 3	19	895343	1921164	440745	-30624 to 1821319
Grp 4	7	6712959	15509347	5861982	-7630718 to 21056636
Total	44	3460275	12046618	1816096	-202231 to 7122782

Group	Minimum Cost	Maximum Cost
Grp 1	0	568916
Grp 2	0	69167180
Grp 3	0	7984185
Grp 4	0	41778043
Total	0	69167180

A KRUSKAL-WALLIS test was conducted on the population of contract changes, with the fiscal year the change occurred as the independent variable and the cost of the

contract change as the dependent variable. Contract changes were grouped by whether they were effective in fiscal year 1982, 1983, 1984 or 1985. Results of the test are displayed in Table 4.17.

TABLE 4.17

KRUSKAL-WALLIS Test Results for Investigative Question 2f

Mean Cost	Rank	Cases	Group	Corrected for Ties	
				Chi-Square	Significance
189639	17.00	3	1982	0.875	0.8313
5845392	23.47	15	1983		
895348	21.95	19	1984		
6712959	24.29	7	1985		

The following null hypothesis was tested:

$H_0$ : There is no difference in the mean cost of contract changes which occurred in different fiscal years.

$H_a$ : There is a statistically significant difference in mean cost of contract changes which occurred in different fiscal years.

The null hypothesis was not rejected for the population of contract changes at a significance level of 0.050. This research concludes that for the LANTIRN FSFD

contract, there is no significant difference in the mean cost of contract changes which were approved in different fiscal years. The effects of inflation were accounted for by the conversion of all costs to a FY1986 base (reference appendices B,C,D, and E). This finding tends to reinforce the research design that all contract changes recorded were from the same stage (FSED) of the LANTIRN contract, since traditionally contract changes become more costly as a program progresses through different stages of the acquisition cycle.

Investigative Question 2g

**Is there a difference between contract change costs which occur before or after the Critical Design Review?**

The purpose of this investigative question was to group contract changes by whether they occurred before or after the System Critical Design Review (CDR). The CDR for the LANTIRN navigation pod occurred during December 1981 and the CDR for the LANTIRN targeting pod occurred during April 1982 (19). All contract changes for the restructured LANTIRN FSED program occurred after these dates. No further analysis was performed for this investigative question. Since there were no contract changes prior to the CDR for the restructured LANTIRN FSED contract, it will not be

possible to determine any cost effect that changes after the CDR may have yielded.

Investigative Question 3a

**Does the establishment of new hardware/software deliverables and schedule delays impact cost versus other contract changes?**

This investigative question groups contract changes by whether the change affects the delivery date of an existing contract line item or establishes a new contract line item. A contract change was classified as having a delivery impact if there was a change to an end item delivery date documented on an AFSC form 706, Supplies Schedule Data, or if a new contract line item was established as documented on an AFSC form 706, Supplies Line Item Data. Group 1 contains contract changes which had a delivery impact, and Group 2 contains contract changes which did not have a delivery impact.

TABLE 4.18

## Descriptive Statistics for Investigative Question 3a

Group	Count	Mean Cost	Standard Deviation	Standard Error	95 Pct Conf Int for Mean
Grp 1	18	12526968	23660408	7482078	-4398668 to 29452588
Grp 2	30	174636	613001	1119818	-54262 to 403535
Total	40	3262717	12601975	1992547	-767590 to 7293024

Group	Minimum Cost	Maximum Cost
Grp 1	0	69167180
Grp 2	0	3089834
Total	0	69167180

A MANN-WHITNEY test was conducted on the contract changes, with the type of contract change as the independent variable and the cost of the contract change as the dependent variable. Contract changes were classified as to whether or not they had an impact on the contract delivery schedule. Results of the test are displayed in Table 4.19.

TABLE 4.19

MANN-WHITNEY Test Results for Investigative Question 3a

Mean	Rank	Cases	Group	Corrected for Ties	
				Z	2-Tailed P
12526960	32.35	10	Delivery	-4.1796	0.0000
174636	16.55	30	Nondelivery		

The following null hypothesis was tested:

$H_0$ : There is no difference in the mean cost of contract changes that have or do not have delivery schedule impact.

$H_a$ : There is a statistically significant difference among the mean cost of contract changes that have, or do not have, delivery schedule impact.

The null hypothesis was rejected for the identified groups of contract changes at a significance level of 0.050. This research concludes that for the LANTIRN FSED contract there is a statistically significant difference in the mean cost of contract changes which have a delivery impact versus those that do not have a delivery impact. The magnitude of the difference in means for the two groups suggests that either the delay of an existing contract line item (CLIN), or the establishment of a new contract line item, or both

factors combined can have a major impact on the cost of a contract. The contract change category involving delivery impacts was not further subdivided to investigate these issues due to the small sample sizes involved.

Investigative Question 3b

Does the establishment of new hardware/software deliverables and schedule delays significantly impact cost versus other contract changes involving SOW changes?

For this investigative question, the population under study is limited to those contract changes which affect the SOW as documented by AFSC form 702. These contract changes are then grouped by whether or not they had a delivery impact, using the same criteria as stated in investigative question 3a. Group 1 contains contract changes which had both SOW and delivery impact, and Group 2 contains contract changes which just had SOW impact.

TABLE 4.20

## Descriptive Statistics for Investigative Question 3b

Group	Count	Mean Cost	Standard Deviation	Standard Error	95 Pct Conf Int for Mean
Grp 1	10	12526960	23660408	7482078	-4398668 to 29452588
Grp 2	5	1709432	1442608	645154	-81774 to 3500637
Total	15	892117	19706275	5083138	-1991354 to 19834088

Group	Minimum Cost	Maximum Cost
Grp 1	0	69167180
Grp 2	0	3335166
Total	0	69167180

A MANN-WHITNEY test was conducted on the subject groups of contract changes, with the type of contract change as the independent variable and the cost of the contract change as the dependent variable. Contract changes were classified as either having a delivery schedule impact, or not having a delivery schedule impact but containing SOW changes. Results of the test are displayed in Table 4.21.

TABLE 4.21

MANN-WHITNEY Test Results for Investigative Question 3b

Mean Cost	Rank	Cases	Group	Corrected for Ties	
				Z	2-Tailed P
12526960	8.15	10	Delivery	-0.1839	0.8541
1739432	7.70	5	Other SOW		

The following null hypothesis was tested:

$H_0$ : There is no difference in the mean cost of contract changes having delivery schedule impact versus other SOW contract changes.

$H_a$ : There is a statistically significant difference in the mean cost of contract changes having delivery schedule impact versus other SOW contract changes.

The null hypothesis was not rejected for the subject groups of contract changes at a significance level of 0.050. This research concludes that for the LANTIRN FSED contract, there is no significant difference in the mean contract change cost between changes impacting the delivery schedule and other changes containing SOW impact. Of the 15 contract changes recorded involving SOW changes, 10 of these had delivery schedule impact while the other 5 did not. The differences encountered in sample sizes may have slightly

altered the observed significance level. Even so, it appears that the factor of whether a contract change altered the SOW had greater cost implications than if a delivery schedule impact was solely involved.

Investigative Question 4a

**Was the page quantity of an engineering change proposal a factor which affected cost?**

Cost proposals for contract changes are often received in the form of engineering cost proposals (ECPs). This investigative question groups contract changes by the page length of the ECP which precipitated the change. Group 1 contains contract changes whose corresponding ECPs were under 20 pages in length, and Group 2 contains contract changes whose corresponding ECPs are greater than 20 pages in length.

TABLE 4.22

## Descriptive Statistics for Investigative Question 4a

Group	Count	Mean Cost	Standard Deviation	Standard Error	95 Pct Conf Int for Mean
Grp 1	6	1186574	1166485	476216	-37558 to 2410707
Grp 2	5	16316821	29696566	13280708	-20555737 to 53189379
Total	11	8063959	20392859	6148678	-5636146 to 21764064

Group	Minimum Cost	Maximum Cost
Grp 1	236130	3196434
Grp 2	200984	69167180
Total	200984	69167180

A MANN-WHITNEY test was performed on the population of contract changes involving engineering change proposals (ECP), with the page quantity of the ECP as the independent variable and the cost of the contract change as the dependent variable. The contract changes were grouped by whether the involved ECP was less than or greater than 20 pages in length. Results of the test are displayed in Table 4.23.

TABLE 4.23

MANN-WHITNEY Test Results for Investigative Question 4a

Mean Cost	Rank	Cases	Group	Corrected for Ties	
				Z	2-Tailed P
1186574	5.00	6	under 20 pgs	-1.0954	0.2733
16316821	7.20	5	over 20 pgs		

The following null hypothesis was tested:

$H_0$ : There is no difference in the mean cost of contract changes containing ECPs of under or over 20 pages in length.

$H_a$ : There is a statistically significant difference in the mean cost of contract changes containing ECPs of under or over 20 pages in length.

The null hypothesis was not rejected for the subject groups of contract changes at a significance level of 0.050. This research concludes that for the LANTIRN FSED contract, there is no significant difference in the mean cost of contract changes containing ECPs of under, or over 20, pages in length. To answer the investigative question, only two groups of ECP page lengths were established (under 20 pages or over 20 pages), to allow for similar sample sizes. If larger sample sizes were available, it would have been

preferable to further subdivide the ECP page length categories to potentially identify any trends which may not have been evident through the use of only two categories.

Investigative Question 4b

Was there a significant cost difference between the lengths of the periods of performance for a contract change?

Contract changes which involve the addition of new work often specify a period of performance for which the work is to be performed. This investigative question groups contract changes by the length of the period of performance involved. Group 1 contains contract changes with less than 10 months specified as the period of performance; Group 2 contains contract changes with between 10-25 months specified as the period of performance; Group 3 contains contract changes with greater than 25 months specified as the period of performance.

TABLE 4.24

## Descriptive Statistics for Investigative Question 4b

Group	Count	Mean Cost	Standard Deviation	Standard Error	95 Pct Conf Int for Mean
Grp 1	5	745797	774872	346534	-216318 to 1707913
Grp 2	5	3232440	2745299	1227735	-176243 to 6641124
Grp 3	3	24281737	38895628	22456401	-72341420 to 120904894
Total	13	7133569	18754064	5201442	-4199397 to 18466536

Group	Minimum Cost	Maximum Cost
Grp 1	200984	2008441
Grp 2	1141923	7984185
Grp 3	481596	69167180
Total	200984	69167180

A KRUSKAL-WALLIS test was performed on contract changes specifying a period of performance, with the length of the period of performance as the independent variable and the cost of the contract change as the dependent variable. Contract changes were grouped by whether they specified under 10 months, between 10-25 months, or over 25 months as

the period of performance. Results of the test are displayed in Table 4.25.

TABLE 4.25  
KRUSKAL-WALLIS Test Results for Investigative Question 4b

Mean Cost	Rank	Cases	Group	Corrected for Ties	
				Chi-Square	Significance
745798	3.80	5	under 10 months	5.5209	0.0633
3232440	8.80	5	10-25 months		
24281737	9.33	3	over 25 months		

The following null hypothesis was tested:

$H_0$ : There is no difference in the mean cost of contract changes specifying differing lengths for the period of performance.

$H_a$ : There is a statistically significant difference in the mean cost of contract changes which specify differing lengths for the period of performance.

The null hypothesis was not rejected for the involved groups of contract changes at a significance level of 0.050. This research concludes that for the LANTIRN FSED contract, there is no statistically significant difference in the mean cost of contract changes which specify differing lengths for

the period of performance. It must be noted that the observed significance level (0.3633) was close to the threshold value required to achieve significance (0.050). With the small sample sizes taken into account, it would be reasonable to suggest that there may indeed be a significant difference among the mean contract change costs for two or more of the groups of contract changes containing different periods of performance. As the length of the period of performance increased, the mean contract change cost was also observed to increase (reference Table 5.12). If this finding was validated, it would imply that by decreasing the period of performance for a contract change to the minimum length feasible, cost savings could possibly ensue.

## VI. Conclusions and Recommendations

This chapter contains the conclusions that can be drawn from this analysis of the contract modifications executed during the FSED stage of the LANTIRN contract. Practical implications that can be drawn and limitations on applicability will be discussed. Recommendations are provided for follow-on studies to further investigate means of increasing the cost effectiveness of acquisition management.

### Conclusions

The data analysis used to answer the 13 investigative questions provided the basis for drawing specific conclusions. Other inferences were made based on the quantities and types of contract changes observed through review of the LANTIRN contract files.

A total of 47 non-administrative contract modifications were recorded to have been executed prior to December 31, 1985 on the LANTIRN FSED contract. Some contract modifications had been initiated prior to the stated date but had not yet received final approval, and thus were not included in the study. Where change orders were involved, one supplemental agreement was executed which confirmed the NTE price and a follow-on supplemental agreement was executed reflecting the final, negotiated price. Unless otherwise indicated, the final negotiated price was used in data analysis for all change orders.

The conclusions of this research are summarized below.

1. Contract changes which affected the Statement of Work had a pronounced cost impact on the contract. The cost of a contract change affecting the SOW was on average several magnitudes greater than that of a contract change within the scope of the contract. Of all variables analyzed, whether or not the change affected the SOW was the most consistent predictor of the cost magnitude of the change. The page quantity of the SOW change was not observed to have any correlation with the cost of the change. Also, there was no significant difference in the cost of SOW changes which affected either the cost-plus or the fixed-price component of the contract.

These findings suggest that a prime method of limiting cost growth to a contract would be to minimize the number of out-of-scope contract changes. This implies that greater care should be exercised in preparing the initial contract SOW to ensure that all known requirements are considered. After this determination, a program baseline should be developed such that all technical requirements are frozen, which would enhance program stability. This would enable more efficiency in the estimation and allocation of federal funds to defense programs.

2. Change orders added significantly to the cost of the contract, as opposed to supplemental agreements. The mean cost of change orders was on average several magnitudes

greater than that for supplemental agreements. The time span required to fully negotiate a change order also may affect its cost, with the relationship being that the greater the time required for negotiation, the greater the cost of the change. These findings imply that change orders should be avoided when possible as a vehicle for implementing contract change, in the interest of minimizing cost growth.

All of the change orders recorded involved SOW changes. No comparison could be drawn between change orders and other supplemental agreements involving SOW changes, because all contract modifications involving changes to the SOW were implemented by change order. Therefore it was not possible to determine for SOW contract changes if there would be any cost difference for implementation by change order or supplemental agreement.

There was also found to be no significant difference between the NTE estimate for a change order, and the final negotiated price. A program manager should therefore pay close attention to the NTE estimate provided by the contractor for a work effort, since the final cost will likely not deviate significantly from this estimate.

The period of time required to negotiate a supplemental agreement after the receipt of a cost proposal was found not to have a significant correlation with cost. Also regarding time, there was no significant difference in

the cost of contract changes which were executed in different fiscal years ( after accounting for the effects of inflation ). This finding would seem to suggest that the stage of contract completion had no effect on the immediate cost of a contract change. However, it must be noted that all of the contract changes reviewed were executed after the system critical design review. Therefore even though the contract changes were occurring over different fiscal years, they were also occurring during roughly the same developmental stage of the program. Thus, the effects of contract changes executed over different developmental stages of the program could not be evaluated.

3. Contract changes which in any way affected the product delivery schedule of the contract had a significantly higher mean cost than changes which did not affect the delivery schedule. However when contract changes which impacted the product delivery schedule were compared with other contract changes which affected the SOW, there was no significant cost difference. This finding implies that whether a contract change impacts the SOW has greater cost implications than if the delivery schedule is affected in addition. Also, if the SOW is not affected by the contract change, then delivery schedule changes provide a greater cost growth than non-delivery schedule contract changes. Such results suggest that changes to the product delivery schedule of a contract will likely provide for some degree of cost growth.

4. All of the design changes recorded involved changes to the SOW and were accompanied by engineering change proposals (ECP). No correlation was found between the cost of the design change and the page length of the engineering change proposal. A tentative connection was found between contract cost and the length of the period of performance established. As the length of the period of performance expanded, the greater was the mean contract cost. Therefore it can be concluded that design changes can add a significant contribution to the cost growth of a contract by virtue of their impact to the SOW. The period of performance required to implement the design change should also be held to the minimum time length possible, in an attempt to minimize cost growth.

#### Recommendations

Presently the LANTIRN program is in the production phase, although some FSED tasks are still undergoing completion. The findings of this research suggest that further out-of-scope contract changes could have major cost implications, particularly at this phase of program development. Additionally, any change to an existing FSED task could possibly force unplanned out-of-scope changes to the production program.

If for unavoidable reasons a change is deemed necessary, it is recommended that change orders be avoided

as a means of implementing the change. A fully priced cost proposal should be requested, upon which a supplemental agreement can be negotiated. If use of a change order is unavoidable, effort should be taken to reduce the amount of time required between approval of the unpriced order and the negotiation of a final price. If the task required involves a period of performance to complete, it is recommended that a minimum amount of time be pursued for task completion. Changes which affect existing product delivery schedules must also be avoided.

This study represents an analysis of the contract files for the FSED phase of the LANTIRN program. As such, all conclusions and implications that have been drawn are only applicable as applied to that particular program. Further research should be conducted to analyze the effects of contract changes on cost growth for other acquisition programs. In this manner, more cost-effective policies for acquisition management can be developed.

Since the LANTIRN program was managed under the Aeronautical Systems Division (ASD), it is recommended that other ASD programs be studied to determine if similar conclusions can be drawn. If trends are identified, then similar studies should be conducted on programs from other product divisions to determine if the same trends exist.

The analysis of the contract files of the LANTIRN program was only for the FSED stage of program development.

Other studies should examine different stages of acquisition programs to determine if the causes of cost growth are in any way connected to the particular stage of program development.

In selecting candidate SPOs for analysis, consideration should be given to the size of the SPO and the quantity of contract modifications recorded. Some of the analysis performed in this study were hampered by small sample sizes. By selecting a major weapon system program for study, a greater diversity of investigative areas can be analyzed with an improved reliability of the data.

# Appendix A: Revised OSD Inflation Rates

----- AIRCRAFT PROCUREMENT (3010)    OSD RATES    MARCH 1986 -----									
FISCAL	BASE YEAR								
YEAR	1978	1979	1980	1981	1982	1983	1984	1985	1986
1978	1.158	1.066	0.971	0.868	0.752	0.727	0.673	0.646	0.621
1979	1.277	1.175	1.071	0.957	0.873	0.801	0.742	0.713	0.684
1980	1.430	1.316	1.199	1.072	0.978	0.897	0.831	0.798	0.766
1981	1.559	1.434	1.307	1.168	1.066	0.978	0.906	0.870	0.836
1982	1.640	1.508	1.375	1.229	1.121	1.029	0.952	0.915	0.879
1983	1.752	1.612	1.469	1.313	1.198	1.099	1.018	0.978	0.939
1984	1.846	1.698	1.548	1.383	1.262	1.158	1.072	1.030	0.989
1985	1.928	1.774	1.617	1.445	1.318	1.209	1.120	1.076	1.033
1986	2.003	1.843	1.680	1.501	1.370	1.257	1.164	1.118	1.074
1987	2.072	1.906	1.738	1.553	1.417	1.300	1.204	1.156	1.111
1988	2.134	1.964	1.790	1.600	1.459	1.339	1.240	1.191	1.144
1989	2.190	2.015	1.837	1.641	1.497	1.374	1.272	1.222	1.174
1990	2.241	2.062	1.880	1.680	1.533	1.406	1.302	1.251	1.201
1991	2.293	2.109	1.923	1.718	1.568	1.438	1.332	1.279	1.229
1992	2.346	2.158	1.967	1.758	1.604	1.471	1.362	1.309	1.257
1993	2.400	2.208	2.012	1.798	1.641	1.505	1.394	1.339	1.286
1994	2.455	2.258	2.059	1.840	1.679	1.540	1.426	1.370	1.316
1995	2.511	2.310	2.106	1.882	1.717	1.575	1.459	1.401	1.346
1996	2.569	2.363	2.154	1.925	1.757	1.612	1.492	1.433	1.377
1997	2.628	2.418	2.204	1.970	1.797	1.649	1.527	1.466	1.409
1998	2.689	2.473	2.255	2.015	1.838	1.687	1.562	1.500	1.441
1999	2.750	2.530	2.306	2.061	1.881	1.725	1.598	1.535	1.474
2000	2.814	2.588	2.360	2.109	1.924	1.765	1.634	1.570	1.508

RAW AIRCRAFT PROCUREMENT (3010) OSD RATES MARCH 1986

FISCAL YEAR	ANNUAL % GROWTH	1978	1979	1980	1981	BASE YEAR 1982	1983	1984	1985	1986
1978		1.000	0.920	0.839	0.749	0.654	0.627	0.581	0.555	0.536
1979	8.7	1.067	1.000	0.912	0.815	0.743	0.682	0.631	0.607	0.583
1980	9.7	1.192	1.097	1.000	0.894	0.815	0.748	0.693	0.665	0.639
1981	11.9	1.334	1.228	1.119	1.000	0.912	0.837	0.775	0.745	0.715
1982	9.6	1.462	1.345	1.226	1.096	1.000	0.917	0.849	0.816	0.784
1983	9	1.594	1.466	1.337	1.195	1.090	1.000	0.926	0.889	0.854
1984	8	1.722	1.584	1.444	1.290	1.177	1.080	1.000	0.961	0.923
1985	4.1	1.792	1.649	1.503	1.343	1.225	1.124	1.041	1.000	0.961
1986	4.1	1.866	1.716	1.565	1.398	1.276	1.170	1.084	1.041	1.000
1987	4.1	1.942	1.787	1.629	1.456	1.328	1.218	1.128	1.084	1.041
1988	3.9	2.018	1.856	1.692	1.512	1.380	1.266	1.172	1.126	1.082
1989	3.4	2.086	1.919	1.750	1.564	1.427	1.309	1.212	1.164	1.118
1990	2.9	2.147	1.975	1.801	1.609	1.468	1.347	1.247	1.198	1.151
1991	2.3	2.196	2.021	1.842	1.646	1.502	1.378	1.276	1.226	1.177
1992	2.3	2.247	2.067	1.884	1.684	1.536	1.410	1.305	1.254	1.204
1993	2.3	2.299	2.115	1.928	1.723	1.572	1.442	1.335	1.283	1.232
1994	2.3	2.351	2.163	1.972	1.762	1.608	1.475	1.366	1.312	1.260
1995	2.3	2.406	2.213	2.017	1.803	1.645	1.509	1.397	1.342	1.289
1996	2.3	2.461	2.264	2.064	1.844	1.683	1.544	1.429	1.373	1.319
1997	2.3	2.517	2.316	2.111	1.887	1.721	1.579	1.462	1.405	1.349
1998	2.3	2.575	2.369	2.160	1.930	1.761	1.616	1.496	1.437	1.380
1999	2.3	2.635	2.424	2.209	1.974	1.802	1.653	1.530	1.470	1.412
2000	2.3	2.695	2.479	2.260	2.020	1.843	1.691	1.566	1.504	1.445
2001	2.3	2.757	2.536	2.312	2.066	1.895	1.730	1.602	1.536	1.478
2002	2.3	2.821	2.595	2.365	2.114	1.929	1.769	1.638	1.574	1.512
2003	2.3	2.885	2.655	2.420	2.162	1.973	1.810	1.676	1.610	1.547
2004	2.3	2.952	2.716	2.475	2.212	2.018	1.852	1.715	1.647	1.582
2005	2.3	3.020	2.778	2.532	2.263	2.065	1.894	1.754	1.685	1.619
2006	2.3	3.089	2.842	2.591	2.315	2.112	1.938	1.794	1.724	1.656

Appendix B: Conversion of FY82 Costs to FY86

Conversion Algorithm =  $\text{FY82 cost} / \text{WTD factor FY82} / \text{RAW factor FY86}$

POOO#	FY82 COST	FY86 COST
39	0	0
41	0	0
43	500000	568916

Appendix C: Conversion of FY83 Costs to FY86

Conversion Algorithm = FY83 cost/ WTD factor FY83/RAW factor  
FY86

POOO#	FY83 COST	FY86 COST
36	3000000	3196434
37	64916580	69167180
47	0	0
52	0	0
53	452000	481596
54	5182	5521
57	16772	17870
58	0	0
59	105000000	11187518
60	0	0
62	0	0
63	0	0
66	1500000	1598217
67	1900000	2024408
68	2000	2131

Appendix D: Conversion of FY84 Costs to FY86

Conversion Algorithm = FY84 cost/ WTD factor FY84/RAW factor  
FY86

POOO#	FY84 COST	FY86 COST
73	0	0
74	0	0
75	0	0
76	0	0
77	295000	298144
78	1550	1567
80	7900000	7984185
82	969900	980236
83	0	0
85	1129883	1141923
86	233640	236130
89	350000	353730
94	3300000	3335166
95	0	0
99	365000	368890
100	1987264	20008441
108	300000	303197

Appendix E: Conversion of FY85 Costs to FY86

Conversion Algorithm = FY85 cost/ WTD factor FY85/RAW factor  
FY86

POOO#	FY85 COST	FY86 COST
112	0	0
113	207825	200934
116	1987264	1921852
117	3195000	3089834
120	0	0
122	43200000	41778043
130	0	0

Appendix F: LANTIRN FSED Contract Modifications

POOO#	TITLE	DATE	COST
35	Restructure/Restart	2/16/83	138535610
36	NERC Detector	1/11/83	3000000
37	SE Price Increase	12/22/83	64916580
39	Revise DD254	8/27/82	0
41	Competitive Fly-Off	9/22/82	0
43	ARPANET Sys Upgrade	9/27/82	5000000(NTE)
47	SE Special Provision	12/17/82	0
52	Deviation/Waivers	4/12/83	0
53	Defin of C/O POOO43	3/28/83	452000
54	Repair of GFE	3/29/83	5182
56	Incorp of Updated CDRL	1/31/84	0
57	Repair of GFP	3/29/83	16772
58	Incorp Rev Sec Guide	3/29/83	0
59	Block I Retrofit Demo and Target Recognizer and Extension	5/31/83	10500000(NTE)
60	Rev Sec Class Guide	4/13/83	0
62	Incorp of Dev/Waivers	9/21/83	0
63	Incorp of Revised Specs for Container Shipping	5/16/83	0
66	Change in SOW, LANTIRN Auto Terrain	7/1/83	1500000(NTE)
67	LANTIRN installed Sys Perform Responsibility	8/25/83	1900000(NTE)

POOO#	TITLE	DATE	COST
68	Mod of GFP	7/29/83	2000
73	Incorp of Dev/Waivers	12/9/83	0
74	Change in Inspection, Acceptance, and Delivery Location	11/4/83	0
75	Incorp of Dev/Waivers and add GFP	12/9/83	0
76	Special Termination Cost Clause	10/31/83	0
77	Mod of Structural Verification Vehicle Pods	10/31/83	295000 (NTE)
78	Replace GFP	11/22/83	1550
80	Defin of C/O P00059	12/27/83	6152000 (FP) 1748000 (CP)
82	Defin of C/O P00066	12/20/83	969900
83	Incorp of Dev/Waivers and add GFP	1/25/84	0
85	Defin C/O P00067	2/16/84	1129883
86	Defin of C/O P00077	3/30/84	233640
89	JOVIAL Upgrade C/O	3/29/84	350000 (NTE)
94	Manufacturing Risk/ Reduction in FCS	7/25/84	3300000 (NTE)
95	Target Recognizer Effort	5/31/84	0
99	EOCM Testing	7/6/84	365000 (NTE)
100	LANTIRN/F-15E Integration and ICWG	7/6/84	1987264 (NTE)
101	Add and Modify GFP	7/23/84	0
103	Dev/Waivers, delete GFP	8/21/84	0

P000#	TITLE	DATE	COST
107	Dev/Waivers,add GFP		0
108	Defin of C/O P00039	9/20/84	300000
112	Revised Acceptance and Testing Program	2/6/85	0
113	Defin of C/O P00099	12/12/84	207825
116	Defin of C/O P000100	12/21/84	1987264 (CP)
117	Defin of C/O P00094	1/15/85	3195000
120	Deviations/Waivers	4/10/85	0
122	Prime Mission Hardware Tasks and Restructure of SE	3/27/85	43200000 (NTE)
130	DD254 Revision	11/19/85	0

Appendix G: Data Groups for Investigative Question 1A

GROUP 1 (IN-SCOPE)		GROUP 2 (OUT-OF-SCOPE)	
<u>POOO#</u>	<u>FY86 COST</u>	<u>POOO#</u>	<u>FY86 COST</u>
39	0	36	3196434
41	0	37	69167180
47	0	53	481596
52	0	70	0
54	5521	80	7984185
56	0	82	980236
57	17870	85	1141923
58	0	86	236130
60	0	95	0
62	0	108	303197
63	0	112	0
68	2131	113	200984
73	0	116	1921852
74	0	117	3089834
75	0	122	41778043
76	0		
78	1567		
83	0		
101	0		
103	0		

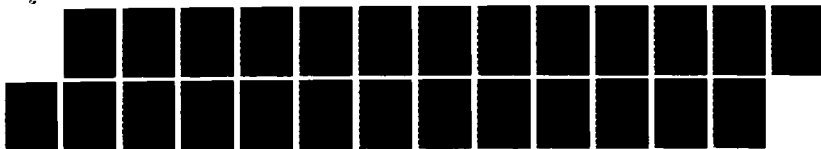
AD-A174 395

AN INVESTIGATION OF THE IMPACT OF CONTRACT CHANGES ON  
COST GROWTH WITHIN T (U) AIR FORCE INST OF TECH  
WRIGHT-PATTERSON AFB OH SCHOOL OF SYST J E BLACKEN  
SEP 86 AFIT/GSN/LSY/86S-2 F/G 5/1

2/2

UNCLASSIFIED

NL





MICROCOPY RESOLUTION TEST CHART  
 NATIONAL BUREAU OF STANDARDS 1963-A

## GROUP 1 (IN-SCOPE)

## GROUP 2 (OUT-OF-SCOPE)

---

POOO#                      FY86 COST

107                              0

120                              0

130                              0

POOO#                      FY86 COST

Appendix H: Data Groups for Investigative Question 1B

GROUP 1 (UNDER 3 PGS)		GROUP 2 (3-5 PGS)		GROUP 3 (OVER 5 PGS)	
POOO#	FY86 COST	POOO#	FY86 COST	POOO#	FY86 COST
86	1921852	53	481592	37	69167180
95	0	80	7984185	85	1141923
116	1921852	82	980236	122	41778043
		108	303197		
		113	200984		
		117	3089834		

Appendix I: Data Groups for Investigative Question 1C

GROUP 1 (COST-PLUS)		GROUP 2 (FIXED-PRICE)	
<u>POOO#</u>	<u>FY86 COST</u>	<u>POOO#</u>	<u>FY86 COST</u>
80	1766627	36	3196434
85	1141923	37	69167180
116	1921852	43	568916
		53	481596
		54	5521
		57	17870
		59	11187518
		66	1598217
		67	2024408
		68	2131
		77	293144
		78	1567
		80	6217558
		82	980236
		85	1141923
		86	236130
		89	353730
		94	3335166
		99	368390
		100	2008441
		108	303197

GROUP 1 (COST-PLUS)		GROUP 2 (FIXED-PRICE)	
<u>POOO#</u>	<u>FY86 COST</u>	<u>POOO#</u>	<u>FY86 COST</u>
		113	200984
		116	1921852
		117	3089834
		122	41778043

Appendix J: Data Groups for Investigative Question 2A

GROUP 1 (CHANGE ORDERS)

GROUP 2 (SUPP AGRMT)

<u>POOC#</u>	<u>FY86 COST</u>	<u>POOC#</u>	<u>FY86 COST</u>
36	3196434	39	0
37	69167180	41	0
53	481596	47	0
80	7984185	52	0
82	980236	54	5521
85	1141923	56	0
86	236130	57	17870
108	303197	58	0
113	200984	60	0
117	3089834	62	0
		63	0
		68	2131
		71	0
		73	0
		74	0
		75	0
		76	0
		78	1567
		83	0
		95	0
		101	0
		103	0

## GROUP 1 (CHANGE ORDERS)

## GROUP 2 (SUPP AGRMT)

<u>POOO#</u>	<u>FY86</u> <u>COST</u>	<u>POOO#</u>	<u>FY86</u> <u>COST</u>
		107	0
		112	0
		120	3
		130	0

Appendix K: Data Groups for Investigative Question 2B

GROUP 1 (CHANGE ORDERS)

GROUP 2 (OTHER SOW CHANGES)

<u>POOO#</u>	<u>FY86 COST</u>	<u>POOO#</u>	<u>FY86 COST</u>
36	3196434		
37	69167130		
53	481596		
80	7984185		
82	980236		
85	1141923		
86	236130		
108	303197		
113	200934		
117	3089834		

Appendix L: Data Groups for Investigative Question 2C

GROUP1 (UNDER 5 MO'S)		GROUP2 (5-6 MO'S)		GROUP3 (OVER 6 MO'S)	
POOO#	FY86 COST	POOO#	FY86 COST	POOO#	FY86 COST
86	236130	85	1141923	53	481596
113	200984	116	1921852	80	7984185
		117	3089834	82	980236
				108	303197

Appendix M: Data Groups for Investigative Question 2D

GROUP 1 (UNDER 3 MO'S)		GROUP 2 (3-5 MO'S)		GROUP 3 (OVER 5 MO'S)	
POOO#	FY86 COST	POOO#	FY86 COST	POOO#	FY86 COST
37	69167180	53	481596	36	3196434
113	200934	85	236130	80	7984185
116	1921352	86	236130	82	980236
		103	303197	117	3089834

Appendix N: Data Groups for Investigative Question 2E

GROUP 1 (NTE)		GROUP 2 (FINAL)	
<u>POOO#</u>	<u>FY86 COST</u>	<u>POOO#</u>	<u>FY86 COST</u>
43	568916	53	481596
59	11187518	80	7984185
66	1598217	82	980236
67	2024408	85	1141923
77	298144	86	236130
89	353730	108	303197
94	3335166	113	200984
99	368890	116	1921852
100	2008441	117	3089834

Appendix O: Data Groups for Investigative Question 2F

GROUP 1 (1982)		GROUP 2 (1983)		GROUP 3 (1984)		GROUP 4 (1985)	
POOO#	FY86 COST	POOO#	FY86 COST	POOO#	FY86 COST	POOO#	FY86 COST
39	0	36	3196434	73	0	112	0
41	0	37	69167180	74	0	113	200984
43	568916	47	0	75	0	116	1921852
		52	0	76	0	117	3089834
		53	481596	77	298144	120	0
		54	5521	78	1567	122	41778043
		57	17370	80	7984185	130	0
		58	0	32	980236		
		59	11187518	83	0		
		60	0	85	1141923		
		62	0	86	236130		
		63	0	89	353730		
		66	1598217	94	3335166		
		67	2024408	95	0		
		68	2131	99	368390		
				100	2008441		
				101	0		
				103	0		
				108	303197		

Appendix P: Data Groups for Investigative Question 3A

GROUP 1 (DELIVERY IMPACT)

GROUP 2 (OTHERS)

POOO#      FY86 COST

36      3196434

37      69167180

53      481596

80      7984185

86      236130

108      303197

112      0

113      200984

116      1921852

122      41778043

POOO#      FY86 COST

39      0

41      0

47      0

52      0

54      5521

56      0

57      17870

58      0

60      0

62      0

63      0

68      2131

71      0

73      0

74      0

75      0

76      0

78      0

82      980236

83      0

85      1141923

## GROUP 1 (DELIVERY IMPACT)

## GROUP 2 (OTHERS)

POOO#    FY86 COSTPOOO#    FY86 COST

95                    0

101                    0

103                    0

107                    0

117                    3089834

120                    0

130                    0

Appendix Q: Data Groups for Investigative Question 3B

GROUP 1 (DELIVERY IMPACT)

GROUP 2 (OTHER SOW CHANGES)

POOO#      FY86 COST

36      3196434

37      69167180

53      481596

80      7984185

86      236130

108      303197

112      0

113      200984

116      1921852

122      41778043

POOO#      FY86 COST

32      980236

85      1141923

94      3335166

95      0

117      3089834

Appendix R: Data Groups for Investigative Question 4A

GROUP 1 (UNDER 20 PGS)

GROUP 2 (OVER 20 PGS)

<u>POOO#</u>	<u>FY86 COST</u>	<u>POOO#</u>	<u>FY86 COST</u>
36	3196434	37	69167180
53	481596	80	7984185
82	980236	85	1141923
86	236130	113	200984
108	303197	117	3089834
116	1921852		

Appendix S: Data Groups for Investigative Question 4B

GROUP 1 (UNDER 10 MO'S)		GROUP 2 (10-25 MO'S)		GROUP 3 (OVER 25 MO'S)	
POOO# COST	FY86 COST	POOO#	FY86 COST	POOO#	FY86
82	980236	67	2024408	36	3196434
86	236130	80	7984185	37	69167180
100	2008441	85	1141923	53	481596
108	303197	116	1921852		
113	200984	117	3089834		

Appendix T: Sample AFSC Form 702-Amendment of Solicitation/Modification of Contract

<b>AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT</b>					REL/lu	PAGE 1 OF 1																						
2. PROG INSTRUMENT ID NO. (PIIN) <b>F33657-80-C-0441</b>		3. SPIIN <b>P00036</b>	4. EFFECTIVE DATE <b>83JAN11</b>	5. REQUISITION/PURCHASE REQUEST PROJECT NO.	6. BDC/DMS RATING																							
7. ISSUED BY <b>USAF/AFSC</b> CODE <b>FQ7615</b> <b>Aeronautical Systems Division</b> <b>Wright-Patterson AFB, OH 45433</b> <b>Buyer: G. Germann, ASD/RWKRC</b> <b>(513) 255-6045</b>			8. ADMINISTERED BY (IF OTHER THAN BLOCK 7) CODE <b>SI002A</b> <b>DCASMA Orlando</b> <b>3555 Maquire Blvd.</b> <b>Orlando, FL 32803</b>																									
9. CONTRACTOR NAME AND ADDRESS CODE <b>04939</b>  <b>MARTIN MARIETTA CORPORATION</b> <b>ORLANDO DIVISION</b> <b>P.O. BOX 5837</b> <b>ORLANDO, FL 32855</b>			10. SECURITY CLASS <b>U</b>  11. DISCOUNT FOR PROMPT PAYMENT <table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td colspan="2">1. NET</td> <td colspan="2">2. DAYS</td> <td colspan="2">3. OTHER</td> </tr> <tr> <td colspan="2">1</td> <td colspan="2">2</td> <td colspan="2">3</td> </tr> <tr> <td colspan="2">2</td> <td colspan="2">3</td> <td colspan="2">4</td> </tr> <tr> <td colspan="2">3</td> <td colspan="2">4</td> <td colspan="2">5</td> </tr> </table>		1. NET		2. DAYS		3. OTHER		1		2		3		2		3		4		3		4		5	
					1. NET		2. DAYS		3. OTHER																			
1		2		3																								
2		3		4																								
3		4		5																								
12. PURCHASE OFFICE POINT OF CONTACT <b>AEE/A35/APV</b>																												
13. THIS BLOCK APPLIES ONLY TO AMENDMENTS OF SOLICITATIONS <input type="checkbox"/> The above numbered solicitation is amended as set forth in block 17. <input type="checkbox"/> The hour and date specified for receipt of offers is extended <input type="checkbox"/> is not extended Offers must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation, or as extended by one of the following methods: (a) By signing and returning _____ copies of this amendment; (b) By acknowledging receipt of this amendment on each copy of the offer submitted; or (c) By separate letter or telegram which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKNOWLEDGMENT TO BE RECEIVED AT THE ISSUING OFFICE PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER IF BY virtue of this amendment you desire to change an offer already submitted, such change may be made by telegram or letter provided such telegram or letter makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.																												
14. THIS BLOCK APPLIES ONLY TO MODIFICATIONS OF CONTRACTS <input type="checkbox"/> THIS CHANGE IS ISSUED PURSUANT TO _____ THE CHANGES SET FORTH HEREIN ARE MADE TO THE ABOVE NUMBERED CONTRACT/ORDER. <input type="checkbox"/> THE ABOVE NUMBERED CONTRACT IS MODIFIED TO REFLECT THE ADMINISTRATIVE CHANGES (SUCH AS CHANGES IN PAYING OFFICE, APPROPRIATION DATA, ETC.) SET FORTH HEREIN. <input checked="" type="checkbox"/> THIS SUPPLEMENTAL AGREEMENT IS ENTERED INTO PURSUANT TO AUTHORITY OF <u>the Terms and Conditions of</u> -IT MODIFIES THE ABOVE NUMBERED CONTRACT AS SET FORTH HEREIN. <b>P00032 and 10 U.S.C. Chapter 137.</b> <input type="checkbox"/> THIS MODIFICATION IS ISSUED PURSUANT TO _____																												
15. CONTRACT ADMINISTRATION DATA <table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td>A. KIND OF MOD</td> <td>B. MOD ASST</td> <td>C. DATE OF SIGNATURE MODIFICATION</td> <td>D. CHANGE IN CONTRACT AMOUNT INCREASE (+) DECREASE (-)</td> <td>E. LOSING PO/CAO ON TRANSFER</td> <td>F. GAINING PO/CAO ON TRANSFER</td> <td>G. BYC/AGENCY USE</td> </tr> <tr> <td><b>C</b></td> <td></td> <td></td> <td><b>\$ 3,000,000.00+</b></td> <td></td> <td></td> <td></td> </tr> </table>							A. KIND OF MOD	B. MOD ASST	C. DATE OF SIGNATURE MODIFICATION	D. CHANGE IN CONTRACT AMOUNT INCREASE (+) DECREASE (-)	E. LOSING PO/CAO ON TRANSFER	F. GAINING PO/CAO ON TRANSFER	G. BYC/AGENCY USE	<b>C</b>			<b>\$ 3,000,000.00+</b>											
A. KIND OF MOD	B. MOD ASST	C. DATE OF SIGNATURE MODIFICATION	D. CHANGE IN CONTRACT AMOUNT INCREASE (+) DECREASE (-)	E. LOSING PO/CAO ON TRANSFER	F. GAINING PO/CAO ON TRANSFER	G. BYC/AGENCY USE																						
<b>C</b>			<b>\$ 3,000,000.00+</b>																									
16. ENTER ANY APPLICABLE CHANGES <table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td>A. PART PAY</td> <td>B. EFFECTIVE DATE OF AWARD</td> <td>C. CONTRACT TYPE (1)TYPE (2)KIND</td> <td>D. TYPE CONTR</td> <td>E. BURY CHIT</td> <td>F. SPL CONTR PROVISIONS</td> <td>G. PAYING OFC CODE</td> <td>H. DATE SIGNED</td> <td>I. SECURITY (1)CLASS (2) DATE OF DD 284</td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </table>							A. PART PAY	B. EFFECTIVE DATE OF AWARD	C. CONTRACT TYPE (1)TYPE (2)KIND	D. TYPE CONTR	E. BURY CHIT	F. SPL CONTR PROVISIONS	G. PAYING OFC CODE	H. DATE SIGNED	I. SECURITY (1)CLASS (2) DATE OF DD 284													
A. PART PAY	B. EFFECTIVE DATE OF AWARD	C. CONTRACT TYPE (1)TYPE (2)KIND	D. TYPE CONTR	E. BURY CHIT	F. SPL CONTR PROVISIONS	G. PAYING OFC CODE	H. DATE SIGNED	I. SECURITY (1)CLASS (2) DATE OF DD 284																				
17. REMARKS (Except as provided herein, all items and conditions of the contract, as heretofore changed, remain unchanged and in full force and effect.) <b>Subject: Acquisition of Infrared Detectors.</b>  <b>Change in Contract Price: \$3,000,000.00 (Increase)</b>																												
18. CONTRACTOR/OFFEROR IS NOT REQUIRED TO SIGN THIS DOCUMENT <input type="checkbox"/> CONTRACTOR/OFFEROR IS REQUIRED TO SIGN THIS DOCUMENT AND RETURN COPIES TO ISSUING OFFICE <input checked="" type="checkbox"/>																												
19. CONTRACTOR/OFFEROR (Signature of person authorized to sign) <b>Martin Marietta Corporation</b> BY <b>Arthur Anlin</b>				22. UNITED STATES OF AMERICA (Signature of Contracting Officer) BY <b>WENDEL J. BOGNER, JR.</b> Contracting Officer																								
20. NAME AND TITLE OF SIGNER (Type or print) <b>Arthur Anlin</b> <b>Contracts Manager, LANTIRN Program</b>		21. DATE SIGNED <b>83MAR18</b>		23. DATE SIGNED (Type or print) <b>26 MAR 83</b>		24. DATE SIGNED																						

AFSC FORM 702  
NOV 78

AFSC-AMENDMENT AFB 104 1000

# Appendix U: Sample AFSC form 705-Supplies Line Item Data

PART I SECTION B OF THE SCHEDULE SUPPLIES LINE ITEM DATA		1. INSTRUMENT ID NO. (PIN) F33657-80-C-0441		2. SPIR P00036 PAGE 4 OF	
4. ITEM NO. 0014 +	5. QUANTITY 1	6. PURCH UNIT EA	7. UNIT PRICE \$ 150,656.00	8. TOTAL ITEM AMOUNT \$ 1,807,872.00	13. CIR
9. SCTY NO. ACN U AH N	11. NBR N	12. FCN AND PART NUMBER		15. CIR	
14. SITE CODES A. POS B. ACN C. POS					
15. HOUR					
16. SVC/AGENCY USE					
17. PR/MIPR DATA					
18. AUTHORIZED RATE A. PROGRESS PAY B. RECON					
19. CONTRACT A. PERCENT FEE					
20. SVC ID NO.					
21. ITEM/PROJ WBR					
22. 1ST DISCOUNT A. DAYS	23. 2ND DISCOUNT A. DAYS	24. 3RD DISCOUNT A. DAYS	25. NET A. DAYS	26. QUANTITY VARIANCE A. OVER B. UNDER	27. TYPE A. CONTRACT
28. DESCRIPTIVE DATA					
<p>ASSURE A SOURCE OF HIGH QUALITY INFRARED DETECTORS IN ACCORDANCE WITH PARAGRAPH 4210.3.6 OF THE STATEMENT OF WORK AERS 79-07, SECTION A, DATED 30 JULY 1982, INCORPORATED HEREIN BY REFERENCE AND CONSISTING OF THE FOLLOWING SUBLINE ITEMS:</p>					
4. ITEM NO. 0014AA+	5. QUANTITY 12	6. PURCH UNIT EA	7. UNIT PRICE \$ 150,656.00	8. TOTAL ITEM AMOUNT \$ 1,807,872.00	13. CIR
9. SCTY NO. ACN U AH N	11. NBR N	12. FCN AND PART NUMBER		15. CIR	
14. SITE CODES A. POS B. ACN C. POS					
15. HOUR					
16. SVC/AGENCY USE					
17. PR/MIPR DATA					
18. AUTHORIZED RATE A. PROGRESS PAY B. RECON					
19. CONTRACT A. PERCENT FEE					
20. SVC ID NO.					
21. ITEM/PROJ WBR					
22. 1ST DISCOUNT A. DAYS	23. 2ND DISCOUNT A. DAYS	24. 3RD DISCOUNT A. DAYS	25. NET A. DAYS	26. QUANTITY VARIANCE A. OVER B. UNDER	27. TYPE A. CONTRACT
28. DESCRIPTIVE DATA					
<p>MANUFACTURE, TEST AND DELIVER COMMON MODULE INFRARED DETECTORS IN ACCORDANCE WITH PARAGRAPH 4210.3.6.1 OF THE STATEMENT OF WORK AERS 79-07, SECTION A, DATED 30 JULY 1982. DETECTORS SHALL BE USED IN SUPPORT OF CLIN 0002.</p>					

\*REPRESENTS NET AMOUNT OF INCREASE/DECREASE WHEN MODIFYING EXISTING ITEM NO.

N = NOT APPLICABLE  
U = UNDETERMINED  
NSP = NOT SEPARATELY PRICED

E = ESTIMATED  
- (IN QTY AND \$) = DECREASE  
+ OR - (IN ITEM NO.) = ADDITION OR DELETION  
CIR: CONTROLLED ITEM RPT RQMT

S = SOURCE  
D = DESTINATION  
O = INTERMEDIATE  
SITE CODES:

AFSC FORM 705  
JAN 80

PREVIOUS EDITION WILL BE USED.

AFSC Form 705 AFM 1000

# Appendix V: Sample AFSC Form 706-Supplies Schedule Data

PART I SECTION F OF THE SCHEDULE SUPPLIES SCHEDULE DATA			1. BROG INSTRUMENT TO NO. (1011)		2. SPIN	3. PAGE
			F33657-80-C-0441		P00036	6 OF 1
4. ITEM NO.	5. ACRN	6. TSP	7. MILSTRIP DOC NO. AND SUFFIX	8. COM ITEM SERIAL NO.	9. ENDING SERIAL NO. (WHEN APPL)	10. CLIN IDENT EXHIBIT
0014AA+	AH					
11. DEL SCHED DATE	12. ENDING DATE (WHEN APPL)	13. DEL SCHEDULE QTY*	14. SCTY	15. SHIP TO CLAS	16. MARK FOR	
A. 84JAN31	A. 84DEC31	A. 1		U		
B.	B.	B.	D.	D.	D.	
C.	C.	C.	E.	E.	E.	
17. DESCRIPTIVE DATA						
ONE (1) EACH MONTH FROM 31 JANUARY 1984 THROUGH 31 DECEMBER 1984 FOR A TOTAL QUANTITY OF TWELVE (12).						
4. ITEM NO.	5. ACRN	6. TSP	7. MILSTRIP DOC NO. AND SUFFIX	8. COM ITEM SERIAL NO.	9. ENDING SERIAL NO. (WHEN APPL)	10. CLIN IDENT EXHIBIT
0014AB+	AH					
11. DEL SCHED DATE	12. ENDING DATE (WHEN APPL)	13. DEL SCHEDULE QTY*	14. SCTY	15. SHIP TO CLAS	16. MARK FOR	
A. 84JUN30	A. 84DEC31	A. 1		U		
B.	B.	B.	D.	D.	D.	
C.	C.	C.	E.	E.	E.	
17. DESCRIPTIVE DATA						
ONE (1) EACH MONTH FROM 30 JUNE 1984 THROUGH 31 DECEMBER 1984 FOR A TOTAL QUANTITY OF SEVEN (7).						
4. ITEM NO.	5. ACRN	6. TSP	7. MILSTRIP DOC NO. AND SUFFIX	8. COM ITEM SERIAL NO.	9. ENDING SERIAL NO. (WHEN APPL)	10. CLIN IDENT EXHIBIT
0015 +	AH					
11. DEL SCHED DATE	12. ENDING DATE (WHEN APPL)	13. DEL SCHEDULE QTY*	14. SCTY	15. SHIP TO CLAS	16. MARK FOR	
A. 84DEC31	A.	A. 1				
B.	B.	B.	D.	D.	D.	
C.	C.	C.	E.	E.	E.	
17. DESCRIPTIVE DATA						

\* REPRESENTS A NET INCREASE/DECREASE WHEN NO + OR - APPEARS AFTER THE ITEM NO.

E = ESTIMATED

- (IN QTY) = DECREASE

+ OR - (IN ITEM NO.) = ADDITION OR DELETION

AFSC FORM 706  
JAN 80

PREVIOUS EDITION WILL BE USED.

AFSC - ADDRESS AFB MD 1974

### Bibliography

1. Aeronautical Systems Division, Air Force Systems Command Contract F33657-80-C-0441 with Martin-Marietta Corporation. Wright-Patterson AFB OH, 16 February 1983.
2. Aeronautical Systems Division, Air Force Systems Command. "Revised OSD Inflation Rates". Official correspondence. Wright-Patterson AFB OH 1 April 1986.
3. Beckstead, Robert W. and others. Defense Economic Issues. Washington: National Defense University, 1982.
4. Brown, William D. "Program Instability: Fighting Goliath," Program Manager, 12: 30-32 (December 1983).
5. Brumm, Harold J. "Property Rights and the Cost Growth of Weapon Systems," Defense Management Journal, 19: 23-27 (January/February 1983).
6. Devore, Jay L. Probability and Statistics for Engineering and the Sciences. Monterey CA: Brooks/Cole Publishing Company, 1982.
7. Emmelhainz, Margaret A. "Innovative Contractual Approaches to Controlling Life Cycle Costs," Defense Management Journal, 19: 36-42 (April/May 1983).
8. Emory, William C. Business Research Methods. Homewood IL: Richard D. Irwin, Inc, 1985.
9. Gaisor, Charles J. "Legal Characteristics and Cost Uncertainties Associated with Contract Types," Program Manager, 12: 19-21 (August 1983).
10. Hardesty, B.A. "The Streamlining Initiative-Removing Barriers to Productivity," Program Manager, 14: 6-9 (January/February 1985).
11. Mittino, John A. and A. Douglas Reeves. "Productivity Improvement in the Department of Defense Acquisition Environment," Program Manager, 13: 14-23 (November/December 1984).
12. Mukherjee, Mrinal K. and Robert L. Bidwell. "A Strategy for Improving Defense Production Yields," Defense Management Journal 21: 10-13 (May/June 1985).

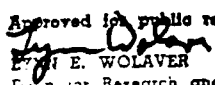
13. Norusis, Marija J. SPSSX Introductory Statistics Guide. New York: McGraw-Hill Book Company, 1983.
14. Power, John R. "A Cost Growth Primer," Concepts, The Journal of Defense Systems Acquisition Management, 5: 93-104, (Spring 1982).
15. Scott, Eugene L. "The Cost Growth Phenomenon," National Contract Management Journal, 16: 37-45 (Winter 1983).
16. Sellers, Benjamin R. "Heavy Hitters Take On Cost," Program Manager, 12: 14-19 (December 1983).
17. Steele, Danton G. "The Strengths and Weaknesses of Multiyear Contracting," Defense Management Journal, 21: 23-27 (January/February 1985).
18. Thompson, William E. "Risk Implications for Cost Growth in Weapon System Acquisition Programs," Concepts, The Journal of Defense Systems Acquisition Management, 5: 116-128 (Spring 1982).
19. Wallis, Richard, Engineer, LANTIRN SPO. Telephone interview. Aeronautical Systems Division, Wright-Patterson AFB OH, 29 May 1986.

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The acquisition of new weapon systems is a multi-billion dollar industry, whose cost is matched in magnitude only by its complexity. Quite frequently the final costs of these weapon systems greatly exceed their original cost estimates. Initiatives have been aimed at acquisition cost reduction, but to a large extent the problem still persists.

The purpose of this investigation is to explore possible means for improving the efficiency and cost-effectiveness of the acquisition management process. This study examines the contract amendments that transpired during the Full Scale Engineering Development (FSED) phase of the Low Altitude Navigation and Targeting Infrared System for Night (LANTIRN) weapon system, managed under the Deputate for Reconnaissance, Strike, and Electronic Warfare of Aeronautical Systems Division. Contract changes and their subsequent costs are grouped relative to their impact on (1) the scope of the contract, (2) the product delivery schedule of the contract, and (3) the design of the weapon system. In addition, various other factors are considered such as the point in contract performance at which the change occurred, the length of the period of performance, the page length of the Engineering Change Proposal (ECP), and the page length of the Statement of Work (SOW) alteration. All costs are adjusted to base year FY86 dollars to control for inflation.

Contract changes affecting the Statement of Work, including design changes, were found to contribute the greatest amount to contract cost. Extensions to the product delivery schedule also contributed significantly to contract change cost. The use of change orders to implement contract change produced increased costs, and no significant difference was found between the contractor's Not-to-Exceed estimate and final negotiated costs for change orders. Future LANTIRN contract changes should seek to minimize these activities.

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